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INTRODUCTORY.

SWIFT's observation has been often quoted as a truth, viz. that "the man who makes two blades of grass, or two ears of corn, grow where but one grew before, deserves well of his country." Surely, then, he who adds to its territorial extent by rescuing lands from the dominion of the ocean deserves still more,—for the one but increases produce, the other may be said to create land. Therefore, great and meritorious as are the efforts of many individuals, as well as societies, towards the improvement of agricultural practices, and the consequent increase of agricultural produce, still more so are those of enterprising persons who employ their skill and their capital in excluding the tide from the fringes of our shores, and in embanking and cultivating those alluvial deposits which Nature seems to have endued with superior fertility, in order to invite the industry and enterprise of man, and to excite him to avail him-

self of this mode of augmenting the supply of provisions, commensurately with the increase of population.

These enterprises, however, are not unattended with hazard, nor unaccompanied with difficulties and dangers. They are expensive, and therefore failure is disastrous; but when conducted with prudence, and attended with success, they may be eminently beneficial to the community and to the adventurers. Any hints, therefore, tending to prevent failure and to promote success must be valuable; and if apology is due for offering such hints, it may be found in the fact, that from my profession as a Land Agent, having been for many years connected much with sea-walling, both in building and repairing, I have been induced to venture some observations on the subject, in the hope of their being useful to those who are willing to speculate in such undertakings;—to country gentlemen whose estates are already protected by sea-banks, or who may be desirous of enlarging and improving their property in this way,—and even to Engineers, who may be required to advise on the best means of effecting the intended object.

No one who is cognizant of the vast engineering works effected in the present day, can be insensible to the great scientific attainments and the practical powers of the present race of Engineers. Sea-banking, or sea-walling, has hitherto formed but a small portion of the practice of Engineers, and that chiefly as connected with piers, docks, harbours, and other marine works, in

which cases embanking is performed on a totally different scale and principle to that of gaining land from the sea, which has till recently been treated as a branch of rural economy, and has been chiefly practised by non-scientific, but ingenious persons, as merely an application of labour which involved no peculiar difficulties. Nor indeed did these difficulties exceed the skill of those whose business it has always been to watch, protect, and repair sea-walls, so long as embankments were confined to the grassy verges of the shore, over which the spring tides but occasionally flowed; but where greater things are attempted, greater skill and deeper consideration are required.

To such cases the hints here given are applied as the result of much experience and observation, and tendered in the nature of evidence, or of that kind of practical information which Engineers themselves, in all their undertakings, are usually wise enough to seek from practical persons.

This subject divides itself into so many branches, each having such minute ramifications, yet each in its place important to the whole, that the most condensed remarks on them separately has swelled this discourse into a volume, in which there is less hope of eliciting any thing very new relative to it, than of collecting together a great number of important and interesting facts and observations,—of classifying them in such a manner as to render them most useful and available

and of affording a comprehensive view of the whole subject.

The shores of the British Isles present many bays and inlets, wherein alluvial accumulations of earthy, animal, and vegetable matter have taken place to great extent. The earthy matter of these deposits has generally for its basis the geological material predominant in the structure of the country; thus, for instance, the débris of the London clay forms the stiff tenacious soil of the Essex and Suffolk marshes, called marsh clay;—whilst the silty sea-sands of Lincolnshire are but a continuation of those vast tracts of rich lowland over which the sea once flowed, and was first excluded by the Romans, since whose time large portions of land have been gained by successive parallel embankments.

On these and other coasts, very great breadths occur of salts, saltings, ooze, mud-banks, slob, sand-banks, or sandy dunes, as they are variously called in different localities. All of them derive their earthy matter from the débris of the land washed down to the sea by the rains, and after amalgamation with diluvial detritus and marine exuviæ, again washed up, and deposited by the tide. When these deposits become stationary and stable, a high condition of fertility results, the tide being excluded, and the soil sufficiently divested of excess of salt to bear land plants. Of these deposits some are only covered with the tide during violent outbursts of the sea; others only at equinoctial spring

tides; others at ordinary spring tides; and others again at every tide.

These deposits are valuable for the purpose of embankment, principally in the ratio of the more or less happy admixture of those argillaceous, silicious, calcareous, animal, and vegetable matters, and of the greater or less prevalence of the tidal waters over their surface. There are other points constituting value, but these, viz. soil and height above tide, are the principal; the others will be noticed in the course of our investigation. Whilst sea-banking is limited to the pasturable verges of an argillaceous shore, only occasionally or at outbursts covered by the tide, little more skill is called into action, than that which consists in raising a sufficient bank or wall of the *ponderous* material, in the most economical manner. But the enterprise of capitalists has extended the desire of embanking lands from the sea to far more difficult subjects than those verdant fringes; and extensive *intakes* are now attempted, where the sands or slobs are covered by every tide, and where only the silicious sands of the shore are available as the chief material for the construction of the bank. In such cases much care and caution, as well as a considerable degree of enterprise to attempt and skill to perform, are requisite; and many considerations become extremely important towards the success of the undertaking; as for instance—the weight of the bank—the width of the base or seat—the form—the

height—the thickness and the facing, all these features being also much governed by the materials of the bank —the materials of the shore on which it is placed, and its exposure to the sea and the prevailing winds. The importance of these points again will be regulated by the manner in which those materials have to be put together—besides the direction of the line of bank; on each of which points a few words are herein employed in elucidating the main objects to be attended to, and on the precautions to be taken in building sea-banks, the expense thereof, and on the respective merits of different subjects for embanking; and the best means of reclaiming the ground embanked; also some remarks on the advantages to be derived from embankments, and some hints drawn from experience, on the support and repair of old sea-banks.

With reference to these plans and intentions, our discourse is divided into the following general heads:

I. The embankment.

II. The eligibility of a shore for embankment.

III. The drainage of the land.

IV. Its reclamation.

V. The expense of these processes.

VI. Their advantages.

VII. The obstacles to embanking.

VIII. The parties to an embankment.

IX. Instances of embankments.

X. The repair of old sea-walls.

I. THE EMBANKMENT,

or that mound of earth by which the sea is to be excluded from the land, and Neptune deprived of a portion of his domains, is the principal feature of our discourse, and we shall consider it under the heads of

1st, Its weight;
2nd, Its materials;
3rd, Its form and features;
4th, The process of embanking;
5th, The proper line of embankment;
6th, The proper situation of a sea-bank.

1st. The *weight* of the bank is a matter of the greatest importance; first, to counterbalance the weight of the sea against it, that weight being augmented by the winds; and secondly, to consolidate and keep down the sand, and to prevent the waters contained in the sands outside from communicating under the bank with the sands on the inside thereof.

This condition of weight is so important, that in some cases of light material, such as peat or some kinds of sand, the safety of the bank entirely depends on it;

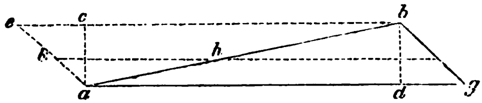
and, in general, a bank must *be rendered* weighty in proportion to the lightness, looseness, or want of adhesion of the materials of which it is composed, either by its bulk, or by means of more weighty materials, such as stone laid upon the lighter materials.

(*a.*) The force of sea water pressing against a bank will be in the compound ratio of its depth and its velocity. Every attempt to reduce these to calculation will be in some degree nugatory, because either may at times greatly exceed the other; but they often act in combination. The bank therefore must be superior to their greatest united force.

The weight of sea water is $64\frac{1}{4}$ lbs. per cubic foot. The weight of earth, *i. e.* gravel, sand, and clay mixed, is stated by some Engineers to be $1\frac{1}{2}$ ton per cubic yard, by others sandy material is considered to weigh from $1\frac{1}{10}$ to $1\frac{1}{4}$ ton per cubic yard. If the weight should be $1\frac{1}{2}$ ton, it will be 125 lbs. per cubic foot. But the weights of the common admixture of materials which are usually employed to form a sea-bank are as follow: —sand 95 lbs., clay 165 lbs., common earth 124 lbs., flint 160 lbs., chalk 112 lbs. per cubic foot, and the average of all these materials is 131 lbs.; but as sand and water will enter into the composition, we have calculated on but 125 lbs. per cubic foot. We may therefore safely take the weight of the materials usually, and almost of necessity, employed in building a sea-bank, to be nearly equal to double the actual weight of the

quiescent water they have to sustain, because the resisting power of the dead weight of earthy and stony matter is greatly augmented, not only by its cohesion, but also by the weight of water which rests on its surface, so that in some degree the weight of water against, or rather upon, the face of a bank, being a gradually inclined plane to seaward, tends to its support.

Supposing the weight and pressure of water to be exerted perpendicularly, then the face of the sea-bank *ab* in the diagram below would only have to sustain the pressure of the water contained in the space *a b c*; but these forces are exerted at an angle of 45° with the horizon, or, in this case, with the horizontal line *ad*, so that the plane *ab* has to sustain the weight of water contained in the space *aeb*, which in its sectional area is one-fifth greater than *abc*.



Now if this diagram be allowed to represent by *a b g* a bank whose height is 10 feet, and base 5 to 1 or 50 feet, its sectional area will be equal to *a e b*, whilst its weight will be about double that of the quiescent water bearing against it.

(*b.*) The weight of quiescent water is, however, but a portion of the stress a sea-bank has to sustain. The pressure of wind upon the surface of the sea, and the

x. Of the Repair of Old Sea-Walls.

almost to solidity, the constant soakage of the tide into the sand on the sea side of the bank will extend under it to the sands on the land side, and the bank will blow up. Some soakage through and below the bank will always take place, and when the ground is adhesive, this can be intercepted by a delph, *i.e.* a drain (which may also be a fence) dug parallel to, and on the land side of the bank; but in loose sands such a drain is dangerous, as the sand will run in and bring down the bank. Nothing therefore but weight can be depended on. Where stone is plentiful this feature may be given by that material in the best manner possible. If otherwise, the next most ponderous material must be used, viz. clay. If that is unattainable by reason of expense, and the sand of the shore to be embanked must be employed, then its quantity must make up for its want of cohesion and weight, and the bank must be large and high, like those Roman banks in the Isle of Ely and in Lincolnshire, which were raised of the silty sand of that coast, now inland and apparently preposterously large and high, but in reality most judiciously constructed with reference to their material.

(*d.*) In the case of any bank having to sustain sharp currents, it must however be endowed with an entire weight proportionate to this extra stress upon its strength. Such currents sometimes set in with great force when the flood tide enters an estuary at a wide

opening which suddenly contracts, and for such augmentations of weight, large allowances must be made in practice, since it is scarcely possible to reduce them to theoretic calculation.

2nd. The *materials* of which the bank is to be constructed govern in a great measure the other requisites to be attended to in its formation. These materials are generally either sandy or clayey, with or without the assistance of stone.

(*a.*) *Sandy* material is the most difficult to manage, and the least to be depended on. If it be used in raising the bank, great part is taken away by almost every tide, of what has been previously collected between tide and tide, and sometimes much more is taken by a tide than was collected between that and the preceding tide. This material melts away like sugar in water, and must be collected again and again to perform the work, which after all is always liable to escape particle by particle;—when dry, running as in an hour-glass through every aperture, or blowing away with every wind; or sinking to a level, when wet. Thus the working with this material is attended with infinite mortification, and at least twofold the cost of any other material upon the spot. Many expedients are in use to prevent its escape; as covering the bank of it every tide with sods, which are removed when the work recommences on the recession of the tide: indeed in the case of those loose running sands

which we are now contemplating, it is absolutely necessary to fix them with from half a yard to a yard thickness of clay outside, according to the exposure. Such sands are also raised and accumulated by placing rows of bushes at nearly right angles with the tidal flow, and the water flowing over those kinds of sands, being turbid, is stilled by the projecting tops of the bushes, and so deposits its warp, and raises or levels the sandy surface. In the case however of such loose sands, no doubt the most effectual, safe, and permanent—consequently the least expensive mode ultimately—would be to avoid using a single shovel-full of such sand, but to bring all the materials for the bank from the nearest dépôt of good material, and lay it upon the sandy surface. It is true that carts and horses being used to raise the bank with such sands, the pressure of these has a great effect in consolidating this loose material, but still it is treacherous, and much of it escapes at every tide, and if thus raised at sixpence per cubic yard, it would be better policy, all things considered both present and future, to incur a charge of one shilling per cubic yard for better material. It may indeed even be fairly doubted whether such a soil be a fit subject of embankment, either with a view to security or to cultivation, and it would be prudent to conclude that such bare and unfixed *running* sands ought in prudence to be avoided until they have become *stable* enough to produce *samphire*

at least, if not swarded with maritime grasses and other salt-water plants.

There is however another kind of sea-sand, locally named "*silt*," which seems when wet to be somewhat muddy and argillaceous, and which in that state not only retains its position when laid up in bank, but seems ponderous and sound. But even this kind of sand dries into a running sand, though not much liable to blow, and less prone to escape than that just mentioned. Such sands are best collected by means of planks and barrows, or by horses and carts, and perhaps the cheapest and best way of embanking with them, in cases where stone is too expensive, is that of raising a bank of great bulk, turfing or gravelling the sea face, and mending every little "peck" or injury as it occurs, until the bank has become so firm as to bear the tide. It would however be extremely prudent either to cover the whole of such a bank with turf or with some feet in thickness of clay, or at least a foot thick of such gravelly or stony earth as would soon admit of vigorous vegetation over *the whole* surface, and to prevent cattle from treading on it for some time. The three sets of banks in South Holland, Lincolnshire, already mentioned, and which the excellent Sir Joseph Banks and other antiquaries attributed to the Romans, are of this kind, being huge amorphous masses, evidently depending only on their bulk for their security.

These banks have now some miles in breadth of land on their sea side, though doubtless more or less exposed to the waves when built, the date of which is unknown.

But the policy of making sea-banks across very *loose* sea-sands is at least questionable, even in cases where the level of those sands admits of a good drainage to seaward, since to bring all the materials from a distant spot may be very expensive, and to throw up the sand itself is dangerous, where they are covered at every tide, and the water dwells long enough to saturate them fully, and that continually, so that in course of time a communication takes place between the water-soaken sand outside or seaside, and that inside or landside of the bank, the silicious particles become separated by the aqueous particles, and when the latter become predominant the bank blows up. This has been experienced even in cases where all the materials were brought from a distance, and the sand untouched, and therefore sea-banks can only be made with absolute security with this material, in cases where the sandy soil is above ordinary tides and covered with vegetation: even then, the bank must be very well packed and covered with mud, so that the water cannot penetrate between its clods when it has shrunk in drying, and it must also be guarded on the sea-side with stone if liable to any great *swash* of the wave. Another fault of sand-banks is their liability to sink, from the finer particles of sand being drawn out by the suction of the retiring wave; and if the smallest

particle of sand escapes, then it will be followed by another and another, the mischief silently going on till it becomes apparent in visible depression of the front and top of the bank, which perhaps may at first be taken for a skrinking or settlement of the materials in that place more than another, or to the consolidation of the sands beneath, and the parties may proceed to make up the deficiency, under the idea that their bank is stronger than before, till new instances attract notice, and the real cause becomes known. It has been found in such cases, that a broad footing of *gravel* increases the seat of the bank and checks the percolation of water underneath it, especially when that footing is made a common road for traffic. If sea-banks are built over, and with sands, it becomes also a very essential point to make use of a great quantity of ponderous stone, not only to break the waves and to prevent their tearing away the face of the bank, but also to *weight* the sand and compress it, so as to bring it to as near an approximation to a solid state as circumstances will admit, and thus lessen the chances of the water insinuating itself amongst the sand forming the foundation of the bank.

After all, no art or expense whatever can always insure a sea-bank on a sandy shore, and in an open exposed situation, from considerable damage. This has been abundantly proved, particularly near Abergele and Rhyll on the Flintshire coast, where only slight signs of such a bank are now seen, after an almost unbounded

expenditure of money and skill: on another bank upon the same coast £7000 was sunk; and though less exposed, scarcely a vestige of it remains. Such, therefore, should only be risked in sheltered spots, and where the rage of the ocean is mitigated by projecting rocks or spits of land, protecting the bank from the inclement points, or the shore is observed to be increasing. But if banks of sand are attempted they should be of ample height and dimensions, and the front or facing guarded with clay, turf, sodding, and stones, besides constant watching and repairing every little breach.

(*b.*) *Clay* is a much better material than the best kind of sand, and the bulk of a bank built with it need not be so great as that of banks built with sand, and its slope also may be less, particularly if stone-faced.

But whether the material be sand or clay, the most special care must be taken in putting it together. Some banks have failed in consequence of the sods even of clay being loosely thrown together by means of planks and barrows, and mixed with loose earth: the water thus being enabled to percolate the earth, surrounded the sods, and rendered them almost buoyant, so that the whole mass separated and dispersed; whereas the loose earth ought to have been either collected under the pressure of carts and horses, or *rammed down hard with iron-shod rammers*, and the sods placed carefully outside to defend the most exposed part.

Even stiff clay requires to be very carefully packed.

This material, which is principally in use in Essex for sea-walling, as embanking is there called, is taken from the saltings or oozy forelands outside the walls, and is therefore in a wet state and very ponderous. It is dug in spits, and packed into a sea-wall by a process called "*flood flanking*," the barrow-men delivering the spits to the packers, who take each spit on a pitchfork, and striking it hard into its place, it adheres closely; but as these spits contract in drying, the crevices outside are therefore filled with mud, which is called "*sludging*." Yet, when the packing has not been carefully performed, or the bulk of the sea-wall has not afforded sufficient weight to close the clods on each other, in drying, open spaces still continue, into which the water penetrates on the sea side, and mice, rats, &c. on the land side; so that if not carefully watched and timely mended, the water is let in to the interior, and a breach ensues. In the case, however, of a bank of clay, or adhesive and weighty earth, the great object is to have the bank *high enough*, its weight and tenacity being generally sufficient to withstand the direct force of the sea, though such a bank (as well as one of sand) breaches by diminution from the rear to the front, when the tide overflows it in any great body: *i.e.* the tide first overtopping the wall washes away the earth at the back, and so cuts through to the front.

(*c.*) *Peat* or bog is also a good material for a sea-bank, not only by reason of its staunching but also its

adhesive qualities when packed in a moist state, so as to form a tolerably homogeneous mass. Its defects are lightness (requiring to be heavily weighted with stone), and aptitude to split in drying, forming crevices. These crevices let in the water, which trickles down in rills, and causes alarm for the safety of the bank; it therefore becomes necessary to open the face of the bank occasionally and to stop the crevices. Peat is supposed to be liable to decay, and run into a black mould; but for this it requires atmospheric influence and changes, and in fact a peat sea-bank, which was opened after being built for 17 years, exhibited the material as fibrous and undecayed as when first deposited. It had been covered and compressed with from 1 to 3 feet of stone and gravel. This peat-bank was built across a sandy estuary, where it was deemed too hazardous to make use of any portion of the sand in the construction of the bank, the points aimed at being its fixation and compressure.

(*d.*) Some banks have been built almost entirely of *stone*, but these have failed for want of staunching, as did that great undertaking at Tre Madoc in Caernarvonshire. But stone, though almost indispensable to weight, and to guard the bank, is not a fit material for the body and bulk of it, since, however well cemented, it can never be laid so as to remain water-tight, and is, moreover, too expensive for this use.

(*e.*) Amongst the materials in use for sea-banks,

gravel may be mentioned as one of the most important, and, at the same time, often the most easily procured.

The uses of gravel are manifold. At the outer edge of the bank gravel is the very best material wherewith to form the lower portion of the slope or facing, where it forms a *natural sea-beach* almost impervious to the water, and also a roadway, the traffic on which consolidates the sand below. In this latter use it may also be applied with advantage to the inner edge or foot of the bank. This material also, being spread over the stone facing of the bank, insinuates itself into the interstices between them, and keeps them better than the best masonry. But the use of gravel should be almost confined to the *outside* of the bank (the internal material requiring to be of the most cohesive kind that can be obtained); a coating of gravel of several inches in thickness being spread previous to the stone facing being applied.

Gravel also might be advantageously used as a *substitute* for stone, in the facing of that portion of the bank which is above the main bank, as shown in the diagram on p. 26. Gravel might, indeed, in many cases, be substituted for stone or any other *facing* of the whole bank; and to qualify it for this valuable application, it is only requisite to give the bank sufficient slope, so as to resemble a natural sea-beach; and if the original shore is muddy, a coating of 6 inches of gravel, over 18 inches of mud, would probably form a facing not to be

surpassed. This, however, must depend on the nature of the subject.

(*f.*) The material on the spot is sometimes rejected, when it might be used to a great extent, and with good effect,—its rejection arising perhaps from its want of solidity and cohesion *when wet*, although when dry possessing both these qualities in a considerable degree, and eminently qualifying it either for banking or fronting, and, in fact, for every position which secured it against becoming again thoroughly wetted when once dried. Thence may be inferred the importance of ascertaining fully the merits of any material on the spot before rejecting it, although *in situ* it may not seem capable of answering the purpose. Thus, a material unsuitable to work tram-roads upon, may yet answer for barrows and planks, and may consolidate when used above the tide, or when not exposed to it. Such a material may also be extremely soft and even flowing when wet, but very hard and *staunching* when dry; all of which, with every other property of such material, should be observed and noted accordingly. Even soft wet mud, costing 3*d.* per cubic yard to throw up, may be fixed and consolidated into cement by the addition of one-third gravel brought to mix with it, costing 1*s.* per cubic yard, making the whole to average 6*d.* per cubic yard,—viz. 2 yards 3*d.* = 6*d.*—1 yard 1*s.*; total 1*s.* 6*d.* for 3 yards. A wall of *pisé* or rammed gravel in a frame might very judiciously be adopted for

2 or 3 feet of the centre of the bank (see 'Thickness of Bank'). On the other hand, some soils are extremely firm and even difficult to pick up in their present site, but when raised and exposed to atmospheric influence resume the state in which they were first geologically deposited: examples of this kind were frequent upon the construction of the Eastern Counties Railway about Chelmsford, where the diluvial clays upon exposure again became mud.

On the whole, it must be concluded, that of the materials for a sea-bank, tenacious clay is the best, and *loose* sand the very worst. All the intermediate modifications of soils will have their respective merits or demerits, but they will be eligible in proportion to their ponderosity — their cohesiveness — and their power of resisting the action of water, either in penetrating or dissolving them: and these soils will be ineligible in proportion to their lightness, their looseness, and their aptitude to run and to blow away when dry, or to melt away when wet.

A mixture of materials, bad and good together, when in a wet state, would probably reduce the whole mass to an eligible condition; and although the expense might be thought too great at first, it might be found economy in the end, and the mixture might be effected by the tread of horses, without much labour previously to the material being laid up on the bank.

In cases also where the material is not very trust-

worthy, an artificial dyke of concrete or of common puddling might be carried up in the centre of the bank, of such width, and commencing at such depth below the shore level, as the case might require.

These, and every other improvement of the quality of the materials, would be attended with a great saving of dimensions, as already instanced in the comparison between sand and clay banks.

3rd. The *form* and *features* of the sea-bank are matters of the greatest moment, although its form appears to have been, until lately, but little regarded; the usual form given to them, from the Roman banks in Lincolnshire to those of the Essex marshes, being most generally a mere steep mound of earth, which in the latter cases has been defended by rows of piles, the spaces between those rows, called "*rooms*," being filled with chalk or stone, stowed closely in, and in some cases fourteen of these rows have been placed tier above tier. But of late years it has been found that another form, more consonant to nature, is better adapted to these sea-defences, and that instead of a steep face, embankments should have a slope in front, resembling a natural sea-beach, and be of sufficient thickness and substance to withstand the assaults of the ocean, whilst they ought to have slope enough in the rear to admit of a luxuriant vegetation; and to effect these objects we propose the threefold bank, of which the diagram on page 26 is a section, consisting of—

1st. *The main bank*, built to the full height of ordinary spring tides, which is taken by way of example at 10 feet. It is 20 feet wide at top, and with a slope to sea side, partly of 5 feet base, and partly of 4 feet base, to 1 perpendicular, as the minimum slopes.

2nd. *The outburst bank*, 5 feet high and 8 feet wide at top, and with a slope of but 1½ to 1, because this part of the bank will have to sustain but a transient stress from the top of the tide, and this only occasionally. On this is set

3rd. *The swash bank*, which, having only to sustain the broken tops of the waves, is but 2½ feet high and 2½ feet wide at top, though its base is 8 feet, and should be made amply sufficient to prevent any part of the highest seas going over the bank.

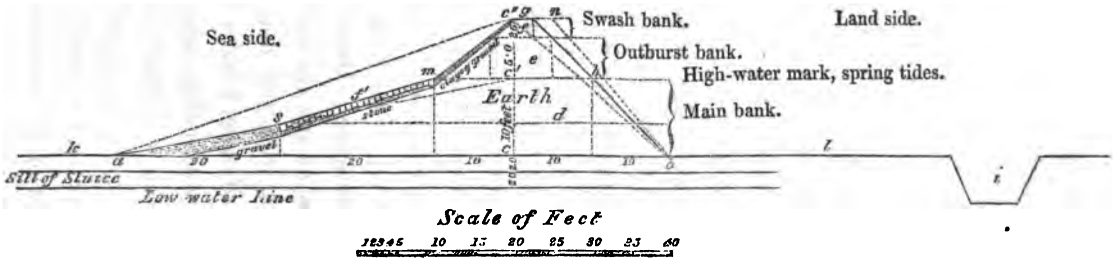
The construction of this diagram is as follows:—

Having drawn the base line *ab*, construct the cubes *d* and *cm*; draw *ac'*, 5 base to 1 perpendicular. Set off 6 feet from the top of the cube *d* towards the base line, for the high-tide wave. Draw the line *ds*, intersecting *ac'* at *s*. Draw *as* and *sm* and *hb*, and this completes the *main bank*, with the double cubes of its height backed by a half-cube, besides the front with a base of 4 to 1, the gravel footing bringing it 5 to 1. For the other proportions construct the cubes *e* and *f*, and draw *mc''*, also *g* and *gh*, giving ample weight, substance, and slope to the bank for ordinary cases.

The rationale of this construction will appear as we

SECTIONAL DIAGRAM OF SEA-BANK.

A.



Scale of Feet

go on, but its outlines are these. The cubes *d* and *cm*, with the half-cube *b h*, are considered to be very ample for the body of the *main bank*, which is 20 feet wide at top. The slope of 5 to 1 is lessened at *m*, to 4 to 1, in order to afford a greater base for the upper bank, and because the space from *m* to *s* is stone-faced, that space being 6 feet perpendicular from the top of the main bank, which is considered to be the usual height of great waves near the shore. The gravelled footing is on the slope of 5 to 1, and is not stone-faced, because the sea has not acquired much force at that height of tide. This completes the main bank. The *outburst* and *swash banks* are drawn with a narrow apex in order to give as much slope as possible to the line $m\,c''$, but where the soil is tenacious, this line may retire still more, and the line *g b* may be steeper.

The essential features of the bank recommended and described in section A are the following:—

a b	is the seat of the bank, or base on which it stands.
$a\ c''$	is the slope.
$c\ c'\ c''$	is the height.
d e f	is the thickness.
f'	is the facing.
g	is the top.
h	is the back.
i	is the delph.
k	is the foreland.
l	is a gravelled footing on both sides.

On each of which features some observations of importance may be made.

(*a*) The general *form* of a bank is required to be such as to receive the wave easily, *i.e.* without any great concussion, or with the least degree of concussion; such as may enable the top of the wave at its highest range to run along the top of the bank, without meeting with any great resistance or sudden check, and such that if the wave should even top the bank, and the swash go over the back of the bank, it may not cut away the soil to any dangerous extent.

The form given on p. 26, in section A, is thought to be such as fulfils all these conditions; and the hollow in front is considered to be such as to reduce the force of the wave when it arrives there, which can only happen at great outbursts of the sea, or when the wave is raised by the wind far above its ordinary height, because the hollow only commences at a point just below the height of equinoctial spring tides, *i. e.* the utmost height of the body of the tide, the wave above that being but transient, and making only a temporary, though it may be a powerful, impression on the upper part of the bank.

(*a b.*) The *width* of the seat or base of the bank should be regulated by the amount of adhesiveness in the material upon which it is placed, and of which it is built, because it is necessary (as already mentioned) to guard against any escape of those materials from the

drawing out or suction of the sand, by the reflux of the wave, or by the soakage of water under the bank.

The width therefore of the seat or base must be such as to throw the sea as far distant as possible from the sandy material, which being prone to run away in minute particles when dry, and to melt like soft sugar when wet, and being equally prone in both states to escape particle by particle, through the smallest aperture, and with a very small declivity, must be kept as much as possible in an undisturbed state. This however is by no means easy, since the waves will be sure to find apertures too minute to be readily discernible, wherein the sands will steal away both in the dry and wet state. Small animals also will burrow in the sand from both sides of the bank, and the apertures thus formed will enlarge by degrees, and may become dangerous before they are observed. Such insidious apertures are very apt to take place amongst and below the stone facing of banks, and should therefore be carefully guarded against. But after all they will inevitably happen, and the only sure safeguard is such a wide base or seat as may give the bank substance enough to admit of rather more than slight apertures and channels without endangering its safety. This substance cannot be given without width of seat, which is therefore an important feature of a sea-bank.

The proper width for the base or seat of a sea-bank will, however, depend much on its other dimensions;

but independently of these, it will be necessary to consider the state of the soil on which the line of bank is proposed, and to ascertain whether it be a sound clay or a loose sand; whether of uniform and firm texture, or interspersed with soft watery spots; whether likely to sustain the weight of a bank, or to yield to its pressure, and spread on each side; whether such as to remain impervious to water, or to admit its percolation, however slowly, from seaward to landward;—in short, whether the foundation on which the proposed bank is to rest be firm or otherwise, *i. e.* compact or porous; for according as it may be one or the other, so must be the width of the seat or base of the bank, whatever its weight, height, or thickness.

This width of seat may be increased, in fact, without adding to the bulk of the bank, by means of a gravelled footing or beach in front, and if this gravelled footing is also used as a road, either during the building of the bank, or afterwards, or both, it will add much to the consolidation of the materials, and to the prevention of percolation. If, again, another such road was used on the inside of the bank, it would also be productive of the same benefit as a wider seat to the bank or sea-wall.

(*a c″*.) The *slope* of the bank to the seaward is one of its principal features of strength and safety. A steep bank enables the wave to strike it with great force, and ultimately to batter it down, or greatly to

reduce its substance, by means of those violent or continuous assaults which the power of the ocean often exercises. In all such cases, the safest plan is to follow nature as far as possible.

The slope of the bank, therefore, should be as similar to a natural beach as all the other considerations will admit. This, however, will depend on the nature of the material:—thus, we may assume for argument, that a loose sandy beach will probably slope itself 10 base to 1 perpendicular; and a living rock will be brought by the action of the sea to nearly a perpendicular, according to its hardness. Therefore, the best line seems to be the medium between the two extreme lines taken in nature, viz. the nearly perpendicular face, and the slope of 10 base to 1 perpendicular, that is, 5 to 1. This, therefore, may be taken as the best slope that can be given to any sea-bank; that more is generally unnecessary, and less insufficient in exposed situations; but that *this* slope need not extend, in ordinary cases, beyond the height of the ordinary spring tides, when another kind of bank may commence, which having only to sustain occasional and transient outbursts of the sea, may have only such a slope as the material will admit. A slope of nearly 5 to 1 in front also lessens the necessity for *thickness* at top of the bank; besides the very important consideration, arising from the compression of the earthy matter of the bank, by the weight of

water upon its face, the degree of such compression, and consequent increase of strength of the bank, being in direct proportion to the degree of slope.

This slope also admits of the easy flow of the sea up and along the inclined plane of the face of the bank; since if stone-faced where the chief stress lies, the waves run harmlessly along the whole face or slope without striking the bank as they would if it were steeper. The stone facing is necessary, for without this a greater substance of bank will be requisite, though strong clay, with a stone footing only, might perhaps be trusted with a slope of 5 to 1, in consideration of its adhesiveness when well covered with suitable vegetation.

But it is expedient also to consider the bank and its slope in three portions, viz.—that from the base to the line of spring tides, which we shall call the *main bank;* that next above, which is to guard against extraordinary *outbursts;* and that which is only to sustain the *swash* or spray of the waves; and to construct the bank as shown in the preceding diagram A, in which the slope *a c′* is 5 to 1 of the height, *c c′*, to which the ordinary spring tides rise. This height is here set out at 10 feet, and the seaward base at 50 feet, which gives a slope almost equal to that of a natural sea-beach on a shingly shore, and greater than that of a shore of large loose boulders.

The whole seaward slope being thus divided in the

diagram A into three portions of different inclinations, each dip considerably and variously from the hypothenusal line of the whole height *a c″*, and this dip in the surface of the front of the bank, which in practice will be worked into a curve, is thought preferable to the straight line *a c″*, because the wave impelled by wind will be less likely to roll over the top of the bank, since the hollow will expend part of its force, and give it a tendency upwards or back again into the sea, whereas the inclined plane will encourage its onward tendency, and enable it to continue under the same impulse till it roll over the bank.

(*c c′*.) The *height* of a sea-bank up to its outburst line and exclusive of the swash bank must depend on two conditions, viz. the rise of tide in the particular locality, and the height to which the greatest outbursts of the sea have ever reached. It is indeed the last-named point that must regulate the total height of the bank, though other points may govern the height of stone facing in land-locked cases. Some marks must be ascertained on the land by the testimony of old people, up to which some outburst of the sea *has* at any time arrived: the greater number of such marks that can be spoken to the better, and the more they agree in horizontal level upon the land the better, but the highest must be taken, even if it should not be very well authenticated. It is sufficient if there be a possibility of the sea having ever flowed so high; and

when it is considered how much the wind forces up the water on the side against which it presses, its flow on that side will occasionally reach heights almost incredible; but whatever that height may be, it must regulate that of the bank, which must be not less than 2 feet above the height of such outbursts in land-locked and sheltered situations, and not less than 3 feet above it in exposed situations, and such as have a long sea-reach in front, so as to occasion a heavy swell on the bank. No escape from these conditions as to the height of the bank can prudently be attempted. It is in vain to conclude, that as the sea has only been known to reach such a height once or twice in the memory of man, it *may* never reach that height again, or at least that the chances are against its reaching that height again, before the embanking parties have effected their purpose. Such a conclusion will be an infringement of *boná-fide* dealing as regards others, and a self-delusion as regards the adventurers. The rules laid down for the height of the bank are imperative, and cannot be neglected with impunity; nay, it will be ultimate economy rather to exceed than to fall short of them.

It is therefore of the utmost importance to determine accurately the three points of height before mentioned, viz. that of the ordinary springs, that of equinoctial springs, and of extraordinary outbursts, and to provide *weight*, *strength*, and *height* of bank accord-

ingly, not forgetting the *swash* of the wave at the top of the highest tide.

In the diagram (page 26), the height of the bank up to the point of the highest ordinary springs is assumed at 10 feet, which is, in fact, a considerable height for any sea-bank, and greater than is generally found to have been hitherto adopted in the intakes of Essex, on which coast these banks are more frequent and extensive than on any other, as 220 miles of them may be measured on the Ordnance Map: of these the author had the management of a considerable portion for many years, exposed to boisterous seas. The equinoctial springs and outburst bank is assumed at 5 feet above this 10 feet, which, being half the height of the main bank, will in general cases be found sufficient; but in the case of very exposed situations, and such as have a great weight of sea on them, or where prevailing winds raise the wave and drive it slanting on the bank, the outburst and swash banks together should approach the height of the main bank,—subject, however, to the ascertainment of actual heights of flow of tide, as before mentioned.

(*d*, *e*, *f*.) The proper *thickness* of the *main bank* is the double cube of its height, supported by a half-cube at the back, and the slope in front for that division of the height, viz., ordinary springs, which we term the *main bank*. The equinoctial springs and *outbursts*, and the *swash*, may diminish to one cube and a half or less.

At each of these respective heights the tide exerts a peculiar force, which, though lessening as the height advances, requires a proportionate resistance; and a double cube of the height of each division, or nearly so, backed by a half-cube, seems to offer that resistance in the most complete manner, since it affords the requisite degree of weight, and also places that weight in the most efficient form, besides securing that degree of economy which is so essential an ingredient in such works.

The double cubes *d*, *m*, and the triangular half-cubes at the back thereof, the cube and rectangular half-cube *e* with its triangular half-cube *h*, and the cube *f* with its triangular half-cube, are the several stages of thickness or bulk which we assign to a well-constructed bank, over and above the frontage forming the slope, and this for the following reasons.

It has been previously shown that the weight of materials comprised in the triangle *a c c′*, together with the half-cube *h b*, are more than equal, under any circumstances, to the resistance of the water opposed to it. The like holds good of the triangle *a*, *c″*, *b*; but the whole height of the bank in the diagram is 17½ feet, and except in open sea, waves seldom, if ever, rise to more than 6 feet, or, in other words, the sea in other situations than open ocean is seldom, if ever, agitated to more than that depth from its surface. We are, therefore, not called upon to provide for the full effect of the weight of this depth of water, but, in fact, only

for 6 feet of it; since, if we supposed 6 feet in depth of water to exert its full force above the line *d*, and upon the face *f'*, it would strike with a force of 6894 lbs., and be resisted by a force of 24,750 lbs.; the one being as the Δ *s m*, and one-fifth more, and the other as the solid contents of the whole 6 feet in height above *d*. Taking also each distinct height of bank separately, it is clear by inspection of the diagram, that each division contains a sectional area over and above that of the mass of water which will be exerted against it; and that this excess amounts in the main bank to double the cube *d*, and in the outburst bank to once and a half the cube *e*. It may, therefore, be safely concluded that this feature of thickness in the diagram gives a bank of weight and strength fully sufficient to withstand the heaviest seas, especially if a central nucleus be worked up with well-rammed earth. In some cases, where the *fertility* or the *locality* render the subject of embankment sufficiently valuable, it might answer well to take up from the foundation a *pisé* wall of gravelly earth well rammed into a *cassoon* or frame, the latter to be removed when filled. We have seen such pisé walls, when just finished, allow of windows being cut in them, and the embedded flints were cut in halves rather than separate from the mass.

(*f'*.) The *facing* of the bank is a matter of great moment, both as to its expense and the degree of security afforded by it. Stone facing is the usual

mode, but previously to the facing with stone a facing of clay should be spread as a foundation for the stone, especially if the bank is built with sand or of any other earth which is liable to run, either in a wet or dry state. The clay facing to the sand should be not less than 3 feet thick, and if over this a coating of gravel be spread, if only 3 inches thick, it will be a great saving in the end, and with such coating the stone must be 15 to 18 inches in thickness or depth from the surface. The manner of stone facing must depend on the kind and form of the stone which is obtainable for the purpose. If it be rounded or boulder stone, it must be mixed with angular stone to give it stability, and in that case promiscuous laying or placing may be better than regular pitching, the several kinds and shapes of stone keying each other, especially if small and large gravel be from time to time spread over the face of the bank, and allowed to take its position either amongst the stone used for the facing, or be washed down to the foot of the bank, where its service will be equally effectual. If the stones be flaggy and flat, it will be necessary to pitch them edgeways, although the action of the sea on their exposed edges is to shake them to and fro until they be loosened and washed out. Still they will not have sufficient bearing on each other to lie flatways, and would slide away into heaps, so that there is no

remedy but pitching, and keeping tight with small stones and fragments. But when the stones are angular and tolerably massive and ponderous, like Kentish rag-stone, 12 to 15 inches in thickness, or less, will suffice, and there is no better way than placing them side by side till the surface is covered, taking care to entangle and hitch the angles of each stone with those of its neighbours; then by encouraging such maritime plants as the soil of the bank will produce, the interstices between the stones are much better occupied than by a continuous mass of stone, since the roots below interlace and keep the stones in place, and the vegetation at top eases off the wave and renders it innoxious.

But it is only in cases of extreme exposure and peril that the whole face of the bank need be protected with so expensive a material as stone. In many cases where it would be prudent to erect a sea-bank, it would be sufficient to guard as much only as might be subjected to the frequent assaults of the ocean, viz. so much as the spring tides reached, as shown in the diagram; above that the attacks of the tide would be few and far between, and though violent, would continue but a short time. It might therefore be enough for safety, to coat that portion above ordinary spring tides with clay and gravel, or clayey gravel, as before mentioned, and to cultivate upon it the plants most likely to thrive, amongst which may be

reckoned the common couch or twitch grass, very much employed in Essex for this use, the net-work roots of which bind the surface effectually; so also does the sand rush (*arundo arenaria*), called Maram grass in Norfolk, where it is much relied on. If the soil be sufficiently fresh, sowing ray grass seeds answers a good purpose, and every locality affords also other plants easily propagated with this view. It may however happen that the surface is of too loose and sandy a nature to be left exposed until vegetation can take place, in which case it must be turfed over; but if that should be impracticable, a coating of gravel must be at all events supplied. Turfing the surface is indeed a common practice when there is no need of stone, but as we are contemplating banks of several miles extent, this mode would scarcely be applicable, and even when the intake is sufficiently swarded to afford materials for turfing, its productiveness is too much reduced.

But there remains another portion of the facing which is most valuable, especially in cases when the bank is built on sand, viz. a gravel *footing*, wide enough to form a road, and renewed from time to time, as the traffic buries the gravel in the sand. This footing, by forming a natural sea-beach, not only prevents the sea undermining, or otherwise "pecking," the bank, but also consolidates the sand and checks the soakage under the bank, a service of the very utmost import-

ance for the purpose of preventing its blowing up. It may be added, that although the gravel in the diagram may appear to some like a loose material to support a firmer one, yet it has been found to answer well in practice; the clayey and sandy matter mixed with it, the action of the tide and the traffic, giving a solidity almost as great, and less likely to be disturbed than that of the stone itself.

The facing is managed in many different ways in different countries. De Luc, in his 'Geological Travels,' vol. i. page 381, describes the method of facing the dykes or sea-banks on the coasts at the mouth of the Eyder, to be that of forcing twisted ropes of straw into the face of the bank, with sticks, in places where the turf had been disturbed. Between these ropes the grass grows again. In other places handfuls of straw are placed in the face of the bank, part of which bending down forms a kind of thatch. The refuse of flax would also doubtless suffice for a time to prevent the abrasion of the soil by the waves, and so would rushes or flags. Any kind of linen or coarse woven fabric, such as hop-bagging or the like, would doubtless temporally protect the soil from further damage, where the turfy covering might be torn up, and so would wads of sea-weed. These latter indeed are much relied on for the sea-banks of the islets near Portsmouth. Trusses of

straw, &c. might also be hastily applied when further damage is apprehended.

In Holland, however, it has been customary to use a great deal of timber in sea-defences, and amongst the modes of using this expensive and perishable material, is that of facing the bank with a framework of strong oak, very accurately built, and the compartments filled in tightly with stone; but such costly modes of expense soon become nugatory, from the constant shake occasioned by the action of the sea, the frames sometimes becoming loosened and letting the stone escape, and sometimes the stone is shaken out, though the frames remain firm. Sometimes, also, the sea finds its way behind this kind of facing, and renders it useless, so that it appears clear that in the facing of a bank we should *"follow nature,"* and imitate, as far as possible, a natural sea-beach whereon the material is of a permanent nature, but so placed as not to give way to the restless action of the wave, otherwise than by finding a new bed immediately below its former one, if that should be slightly reduced by continual washing, and any thing beyond a slight reduction will be inadmissible; and hence in treating of the proper substances for facing, it will not be irrelevant to mention those which, though sometimes used, are found to be improper for this purpose. Such are all kinds of

cement, or material laid in cement, which, however tenacious, sooner or later inevitably crack and break away, or become undermined and lose their earthy support, from the continued agitation of the sea and the constant change which the earth of the shore is undergoing. Hard materials, therefore, with a firm natural individual bearing on the soil, which are thus free to regain that bearing when disturbed, are the only substances to be depended on without incessant renewal.

(*g*.) The *top* or *apex* of the bank is a feature of which the only question is the width of it, and this must depend greatly on the nature of the material with which the bank is built. If topped with stone, the narrower the better, to prevent a footpath or the tread of cattle, which might displace the stones, and then it might be brought up to a sharp edge. If the material of the bank be clay, two or three feet of width at the extreme top will suffice when swarded over. The width given in the diagram of 2½ feet at the extreme height is sufficient, because the sea-defence of that bank does indeed stop at the second or outburst height where it is five feet broad, the *banklet* above that being only added to prevent the swash going over, and as a guard against any very extraordinary but transient outbreak. This kind of banklet is in the fens of Lincolnshire, &c. called a "*cradge bank*," supposed to be a corruption of *scratch*

bank, from being hastily scraped together on the top of the main bank to stem the overflowing of the waters till they subside, and so to stop a threatened inundation; and the width at top of it may be proportioned to the height of the bank by adopting the proportions of the diagram, viz. half the height of the main bank for the outburst bank, and half the height of the outburst bank for the swash bank, which, however, should always be kept up by repairs, as the shrinking of the newly deposited materials, and the washings of the rains or tides, may reduce its width or height.

But if the material of the bank be sand or sandy earth, the width of the top must be greater, and the slope and the slope at back greater also. This extension of width must be proportioned to the looseness and want of weight or cohesion of the sandy material, and even then care must be taken to cover its surface with vegetation as soon as possible. In ordinary cases, however, where the width of the top of the bank is required to be greater than in the diagram, say 4 feet, such width may be given by the addition of the space at *n*, without destroying the proper slope of the back of the bank.

(*h*,) The *back* of the bank will require not only such a slope as will enable the material to stand well, but also such as will admit of a good and firmly established vegetation, and this degree of slope

will depend much upon the material of the bank. Good ponderous adhesive earth will stand well at a slope of 1 to 1, or less, and the slopes of the back of the bank in the diagram are so, of each of the three thicknesses, and this is a good and sufficient slope for any earthy material that is likely to be employed in the construction of a sea-bank, and upon this slope vegetation is sure to prosper. The sea-banks of silty sand on the coast of Flintshire are sown with lucerne, the crop of which is large and valuable, being in a district abounding with horses employed in mining. The roots of this plant are strong and elastic, and penetrate deeply, so that the recently collected materials are firmly bound together for several years, when the grasses gradually overcome the lucerne, and a strong external sward takes its place. For ordinary localities, however, it may be as well to secure the surface of the back of the bank as early as possible with ray grass, couch grass, and such strongly rooted grasses, and maritime or brackish plants, as can best be obtained on the peculiar soil, since it is first on the back of the bank that any impression is made by an accidental overflow of the tide. This part once giving way, the bank is eaten away by the overfall of the wave from back to front, by a process called "pecking" by sea-wallers; the sea then breaks in, and a "breach" en-

sues. The safety of the bank, therefore, much depends upon the security of its back.

(*i.*) The *delph* or drain, which in Essex and elsewhere, in strong soils, is dug on the land side of the bank or sea-wall, for the double purpose of a drain and a fence, is a feature of some importance, inasmuch as if dug too near the land foot of the bank, it may be injurious by favouring and promoting the percolation of water from the sea side to the land side, under the bank, and in cases where this effect is not so likely to take place, by reason of the adhesive nature of the soil, as in more porous soils, the danger is still imminent of its causing the base of the bank to slip and give way. On this account alone, on some occasions, several miles of delph have been filled up, and dug afresh at a greater distance from the bank foot. Twelve yards from the foot of the bank is the true distance, even where no roadway is intended, but it will always be found convenient and judicious to set out the space wide enough for a driftway between the bank and the delph. The delph should not be nearer, although there is a great temptation to bring it nearer during the building of the bank, in order to make the materials from its excavation available for the bank at a smaller distance. The usual dimensions of the delph, when cut independently of its materials, are 12 feet wide at top,

6 feet wide at bottom, and 4 or 5 feet deep; generally, for a fence against cattle, 3 to 4 feet depth of water is requisite. The water should stand 18 inches or 2 feet below the surface of the land; but when the material out of this necessary excavation is reckoned on for building a part of the bank, then the dimensions of the delph are arbitrary. Sometimes they are enlarged into a lake, which becomes dangerous to the stability of the bank, when both its seaward and landward feet are laved with water, the one tidal, the other perpetual, so as to promote that junction and co-operation between the two waters which ought not on any account to be permitted, but towards which they are always tending. It is therefore by far the best plan to get all the materials for the bank from the sea side thereof, and to use the materials arising from the delph in footing and strengthening the bank. In some cases, however, as in soft, loose, sandy soils whose tenacity is insufficient to enable their sides to stand in excavation, the delph must be omitted, as it might tend to bring down the bank, and only a slight rill or channel be permitted to carry off the soakage from the bank, which, in such a soil, must be considered as inevitable.

In soils which have an ordinary degree of tenacity and adhesiveness, and the excavated sides of which will stand, the delph is highly useful in keeping the

bank dry, and carrying off any water which might otherwise remain stagnant.

(*k.*) The *foreland* of a sea-bank is that portion of the ooze, slob, saltings, or mud-banks, which is left unembanked, or on the sea side of the embankment. And there is certainly no feature appertaining to a sea-bank of greater importance than this, since it acts as the advanced guard to the bank itself, receives the first shocks of the sea, and deadens its force upon the bank, by decreasing the depth and bulk of the wave. The broader, therefore, the foreland, and the higher above low-water mark, the greater its protection to the bank. In Essex, a county so famous for its sea-walls, the foreland generally stands several feet above low-water mark, and some hundreds of yards outside the bank, and where it wears away, its edges are scarped and stoned to prevent the loss of so valuable a defence to the sea-wall.

But we do not now confine our contemplation of possible intakes to such as those of Essex, but embracing those mud-banks which are covered by every tide, we still deem some breadth of foreland absolutely necessary in front of the embankments of such intakes. Parties making such embankments will naturally wish to enclose all they can, and will even perceive some advantages in getting as near to low water as possible, so as to insure an open channel for the inland waters; but it will certainly answer the

purpose of the boldest undertaker, to leave at least one hundred yards in breadth outside his intake. The chances are, that this will accumulate, and there will then be an increasing protection by lessening the depth and force of the wave upon the bank, whereas, without a foreland, the depth and force of the sea are exerted against the bank without any mitigation.

Of (*l.*) the *gravelled footing* to the bank on each side, there is little to be added to what has been already said,—as to its forming part of the slope of 5 to 1; as to its use in consolidating the base or foundation of the bank; as to its forming a good and useful road, the traffic on which might also greatly tend to consolidate the erection; as to its cheapness as a material for so much of the bank, and its forming a natural sea-beach of great value. All these points have been mentioned, and need not be further enlarged upon.

4th. The *process* of, and the precautions requisite in, building sea-banks, are very momentous considerations, which we shall notice under the following heads, viz.: (*a.*) General observations. (*b.*) When the material on the spot is used. (*c.*) When the material is to be brought from a distance.

(*a.*) Of the *general precautions* necessary to be observed, there is one paramount, viz. to avoid doing the work twice over, *i.e.* by preventing, as much as

possible, the material collected from being washed away by the sea as the work proceeds, and to do what is absolutely necessary for the permanent security of the bank, but no more. These objects will be accomplished by some men at half the expense that others will incur, and it will be no small help towards the economy and success of the work for its chief practical director to have clear notions of its difficulties, previously to its commencement. These difficulties are, even in the most favourable cases of sea-banking, great and numerous, and even at the best, usually keep the ingenuity of the most skilful and experienced on the *qui vive*, whilst difficult cases engage their cares and anxieties night and day. The first object is to ascertain whether the soil of the space to be embanked, or any portion of it, be fit for the bank; if it be, much care, anxiety, and expense are saved, for then it is only requisite to collect the earthy matter into a bank, in the most convenient manner, so as to fulfil the conditions already stated; but even in this case it will be necessary to use the precaution of building the bank from the two ends, approaching each other towards the place of "shutting up," as it is called, *i.e.* closing, or finally excluding the sea; and each end should be of the full height, or at least the full height of spring tides; because wherever the tide overflows an incipient bank, much of the material

is washed away, and the mischiefs that otherwise happen are considerable. The bank therefore should be built up to its safe height at once.

If any creeks, rills, or deep gullies are to be crossed, the loose "slush" is first to be scraped away, a paving of stone laid, not only over the whole space to be occupied by the bank, but also at least 10 yards beyond that space on the land side, and more than 20 yards on the sea side, and on each side they must be spread fanlike. This is to sustain any current that may take place at the reflux tide, and if the ground is tender and the stones not ponderous, they should be laid in portions of heath, furze-bushes, sticks, or even straw, so as to give them mutual adhesion and support. A great effort should be made to stop out the tide at once from the creek, for which end a great quantity of material should be gathered on the edge, ready to be poured in quickly, at low neap tide, and fine weather being chosen for the purpose. A narrow bank may do at first, if of sufficient height, and it may afterwards be strengthened at the back with earth rammed down, and with stone in front thrown down, and permitted to find a footing.

As the line of bank advances along the shore, much watchfulness will be requisite; currents will be formed by the disturbed action of the tide, "gulls" (pits) will be formed, former channels will enlarge, and new ones appear, and the shore itself will seem

in places to be tending seaward. To meet these symptoms, stores of stone, of grass turf, and of heath, furze, fir tops or bushes should be provided at an early stage of the work. The loose or failing earth should be retained in its place by a judicious use of these materials, which themselves may require to be retained by piles, for which Scotch fir thinnings and boughs of little value may be used. These precautions will probably be more particularly requisite as the two ends of the bank approach each other, towards the place of shutting up. The tidal way will then be contracted, and the rush will be great, both of the influx and reflux of tide. Much of the material at the ends of the bank will thus be carried away, unless guarded with turf kept down with stone during the flow of tide, and removed at its reflux when the work is renewed. And if there should be any disposition in the earth of the shore to be moved by the tidal stream, it must be prevented by the sort of pavement of stone already mentioned, and fanned out to a sufficient extent to enable the soil to bear the current without being removed.

Much judgment is required in choosing the place of shutting up. This is often fixed at the deepest part or main channel, as the natural inlet and outlet of the tide, and sometimes no other can be adopted; but it will be matter of serious thought, whether the shutting

up could not with advantage take place on higher ground, and the main channel be crossed by the bank previously.

It is true that this will impound a lake inside, of the same extent and depth as the channel, but this water will be ultimately worked out by the sluices; and by having higher ground to shut up on, longer time will be gained for working between tides, and less material will suffice. It should also be considered, whether two or more "gaps" are not preferable to one.

But wherever the shutting up takes place, care should be taken to collect sufficient material of every kind likely to be wanted to shut up *in one tide;* and with this view, the two ends of the bank must be advanced accordingly with guards of turf, heath, and stone, as already mentioned. As the earth thrown in attains a position ranging with the general front line of bank, it should be covered with stones thrown down at random, but close, and secured with spray of some kind as a key. A boom also across the gap is often useful, whilst shutting up, to check or equalize the current.

In very difficult cases, sand-bags, *i.e.* about half a cubic yard of any kind of ponderous earth enclosed in coarse hempen bags, must be provided in great numbers, ready to throw into the gap at such critical moments as may require the most strenuous exertions for the purpose of shutting up between tide and tide,

because shovel-fulls of earth, and even large stones, are carried away by the force of the current; whereas these sand-bags are weighty, and contain many shovel-fulls, though taking scarcely more time to throw in than one shovel-full, and they afterwards accommodate their forms to each other, and pack very closely together; but they should be afterwards guarded by a coating of stone outside, and staunched with a thick backing of adhesive ponderous earth on the land side.

The sea being shut out, it remains to make up the bank to its full height, *i. e.* by adding what we call the *outburst* and the swash-banks. This may be done with the material from the "delph," dyke, or drain, dug on the land side, mentioned previously, provided the soil thereof possesses the properties of weight and cohesion in a sufficient degree to be eligible for that purpose.

A very important precaution is to divide the intake into as many portions as circumstances render convenient, making so many separate intakes or levels, since an intake of moderate size is much more manageable and less expensive per acre than a large one; and if any rivers cross the ground, as is almost sure to be the case in large undertakings of this kind, it is much better on all accounts to construct separate, independent intakes between those rivers, even if they should be but insignificant streams, than to attempt to enclose such streams within the bank, and afterwards sluice them out, because, however contemptible such

streams may be in summer, they almost always (especially in mountainous countries) pour down a vast quantity of water at particular seasons, which it may not be possible to carry off in time for vegetation. And in banking out such rivers and streams care must be taken to embank them quite as securely as against the sea, leaving them a good wide berth diverging gradually but sufficiently towards the sea, and taking care that they disembogue clear of the sea-bank. And even if there should not be rivers or streams intersecting any space within 700 to 1000 acres area designed for an intake, it would be prudent still to return the bank to land when that space was gained.

But when the soil is treacherous, still greater precautions are requisite, and much more ingenuity and watchfulness in foreseeing and providing for untoward events, besides a considerable degree of coolness, judgment, and skill in remedying, at the instant of their occurrence, such events as could not be foreseen.

Hence the men employed on the bank as foremen of the works must possess the rare qualifications of much knowledge of what they have undertaken, joined to steadiness, coolness, and great temper, and management of the workmen, whose respect and confidence they must possess, not only as to skill, but as to fair dealing and respectability of conduct. It is always worth while to pay a man so qualified handsomely, and in several instances such men have proved as

anxiously intent on success, and as earnest to obtain it at the least possible cost, as if they were spending their own money for their own benefit. Others, however, are reckless of cost, and only intent on effecting the object; but when a proper degree of confidence is reposed, so that the man feels himself relied upon, and rather consulted than ordered, so as to enlist his feelings and character in the work, he will, in most instances, bring to the service an almost incredible degree of vigilance, activity, anxiety, and ingenuity.

There are many objections to embankments being done by contract; for, in the first place, no man can estimate what no human foresight can contemplate,—no man can foresee in difficult cases how much work is to be done, because the wash of tides will cause some work to be repeated, though he may know well enough how much is to be finally left done; and even if the quantity of labour could be foreseen, as easily as that of a building or inland banking, it is bad policy, in any one interested in the *result*, to depend on any parties not so interested: like the acknowledged impolicy of letting woodlands, because the tenant's immediate interest militates against the owner's reversionary interest,—so the contractor's interest is but immediate, and though he may fulfil his contract honourably, it being impossible for either himself or the owner to foresee everything that may be requisite, both may, and most likely will, be disappointed, since such works

as embanking always require more labour and cost to effect than can possibly be foreseen, nothing happening to accelerate, but a thousand things to retard, the work. In all such contracts nothing is more common than for a contractor to bind himself to a specific time for completion of the work. Yet nothing can be more imprudent, since such work is liable to so many accidents of tides, storms, turn-out of men, difficulty and delay as to materials, &c., that no human being can foresee the exact period of completion, even with the utmost diligence. Yet the proprietor should have security for due diligence being exercised; but how is this to be tested, since it cannot legally be referred beforehand to any neutral person to judge? and perhaps the best security is to withhold a portion of the payment until the work is complete according to contract, to be certified by some competent and neutral person.

Other precautions of a general nature are well worthy of attention, viz. to raise the bank to its *full* height as soon as possible, and to allow in so doing for its *settling* and shrinking from one-eighth to one-fifth of its height, and also to let the earthwork remain, for one winter, without any stone facing, till it is seen what effect the sea has upon the bank, what slope it *takes*, and how far it may consolidate and take a natural bearing, before the external facing is put on. It is true that some little escape of materials may take

place, but this would be much checked by well ramming the earth in front, after covering it with a thin coating of gravel; and the loss will be amply compensated by additional solidity, by the saving of one year's interest on the cost of stone facing, and by the absence of that confusion which takes place when several different works are going on together upon a confined space.

With every possible precaution, however, a new sea-bank will seldom be completed without one of those accidents called a *breach*, viz. the blowing up and carrying away of a portion of the incipient bank, and often of part of the soil of the intended intake to a considerable depth. This usually happens in consequence of the water penetrating the loose earth thrown up, and is attended not only with considerable expense of restoration, but also with a great diminution of that favourable *prestige* towards the undertaking which it is desirable to cherish.

These breaches might often be prevented by the simple operation of giving cohesion to the materials by *ramming them down* as the bank advances, a very slight degree of consolidation in addition to the natural weight of the earth being sufficient to prevent the percolation of the water to any mischievous degree. And even should a breach happen after all, it is by no means so awful an occurrence as generally regarded, but simply an addition to the cost,—a matter, however,

to be at all times avoided, and therefore to be carefully guarded against. Such breaches often happen by reason of some spot along the line of bank which is less firm, *i.e.* more watery and soft, than the rest; hence the necessity of previous examination of the line, and the precaution of rendering such spots firm and sound as a foundation for the bank.

(*b.*) In cases where the *material* of the slob or shore to be embanked is *applicable to the building* of the bank, much expense and delay may be avoided, and there can be but few cases where that material is wholly inapplicable, since any soil which is so entirely devoid of argillaceous matter, as to require to be wholly rejected, can hardly be a fit subject for an intake. In general, indeed, the whole or nearly the whole of any sea-bank may be thrown up from its own vicinity, either by means of barrows running on planks, or by horses and carts, either of which may be accomplished at an expense of about sixpence per cubic yard; and one of the advantages of these modes is, that as much force as is wished may be employed along the line, and the work done in the shortest time possible, *i.e.* within the working days of one season, reckoning 200 days from the 1st of March to the 1st of November, so as to obviate the necessity of leaving the unfinished bank to the "pelting of the pitiless storm" for a whole winter.

In cases where *all* the bank cannot safely be built

with the material on the spot, it will be necessary to determine what portion of it that material is fit for, since it may be extremely ineligible in a wet state, but quite the contrary when dry. It may often be highly eligible for the parts above ordinary springs, or for the front of the bank beneath the stone-work, when it sets hard after being wet, or it may do for the back of the bank, when covered over with vegetable mould. All this must be well considered, taking into account at the same time, that any saving of expense which detracts from the stability and permanency of the bank is very bad economy, and the worst policy.

Amongst other precautions in building a bank with the materials which the line of bank affords, one is most important, viz. to go out to some distance for them from the sea-foot of the bank, so as to avoid causing deep water at the immediate foot. Another precaution is to avoid favouring any channels; and to this end, digging away the earth in spots with bars left between them. If the water comes up at all turbid, these hollows will soon fill with warp. A channel along the foot of the bank is particularly to be avoided as probably mischievous.

It seldom happens, in the case under notice, that carts and horses can be largely employed to collect the materials, by reason of their wetness and softness, or from the rills and inequalities of the surface. Planks, barrows, and "box-horses," are therefore the usual im-

plements employed; and according to Mr. Mylne's evidence before the Committee of the House of Commons on a Railway Line, "four men can fill and wheel 60 cubic yards of clay a distance of 20 yards per day for 14*s*., which allows each man 3*s*. 6*d*. per day, and averages $2\frac{1}{8}$*d*., say 3*d*. per cubic yard, allowing 1*d*. more for each additional 30 yards." This was also his father's rule, and is important, not only in ascertaining what quantity of work can be done in a given time, but also its cost in this mode of collecting the materials of a bank.

It is an advantage of barrows and planks, and in some degree of horses and carts, that they admit of any number of hands being employed, so as to exclude the sea in one season,—this being of great importance, in order to prevent its ravages upon an unfinished bank. Thus it becomes expedient to have several reaches or portions of the bank going on at once, by different gangs, and this will occasion several gaps or places for closing, which will be an advantage, since the force of the reflux tide will be divided, and the closing more easily effected.

(*c*.) In cases where the earthy matter for the bank must be *brought from a distance*, a much greater array of machinery must be employed. In some cases it has been brought in barges where they could be loaded from the shore, but the best way is thought to be by tram-roads and tip-waggons, the experience of which

has become diffused by railway practice, so that there needs but one caution in collecting materials for the bank by them, viz. to build the bank to the full height as soon as possible.

The advantages derivable by the use of tram-roads are, however, much diminished by the original cost of them, and by the loss of time in placing and replacing them. They are also liable to the objection of depositing the earthy material loosely without any assistance to its consolidation,—an object found to be better attained by horses and carts, which might, with a little ingenuity, be so worked in collecting the material, either on the spot or from a distance, that the weight of the carts and the tread of the horses might be available pretty uniformly over every portion of the bank; and where this is not done, the ramming of all the earth that is loosely cast should be adopted, in order to consolidate and give it that cohesion which is one ingredient in its strength, besides preventing or checking its loss by the washing of the tide, which latter effect alone would in some cases repay the expense of ramming; and in one case I have known a breach, and 10,000 acres, drowned, where ramming would certainly have prevented that catastrophe.

As to the expense of the machinery in embanking by means of tram-roads and waggons drawn by horses, it appears by the evidence of Mr. Robert Stephenson

on the Great Western Line, that a contractor's stock was then worth

For rails and chairs . . .	£2587
For points, crossings, &c. . .	287
For waggons	575
	£3449

and that they will be worth, when the work is done, *i. e.* in two or three years,

The rails, &c. one-half . .	£1293
The points, &c. one-third . .	96
The waggons, one-fourth . .	144
	1533
The difference will be . .	£1916

which, on three miles of such a bank as the diagram, enclosing 1000 acres, will be about 1½*d.* per cubic yard, and this is exactly what Mr. S. makes it by another mode of calculation. This mode of doing the work is therefore best calculated for large undertakings, or for those who are already possessors of such stock or plant which may have been before used on railways, &c.

Of sleepers, Mr. S. says that 3000 are required for a mile, and they cost, if permanently good larch or oak, 6*s.* or 7*s.* each; Scotch, about half, but the latter soon decay. Now, however, good tram-road sleepers may be had at much less money.

The use of locomotive engines to draw the waggons is condemned by some engineers as not applicable, with any advantage, at less distances than two to three miles; they are then by some reckoned to cost, all things considered, very nearly as much as horses and carts; by others, where earth is moved by horses and carts at 6*d.* per yard, it may be moved by locomotive engines at 4½*d.* per yard. By others, the working of locomotive engines is reckoned at 2*d.* per yard per mile, although the engine itself may be hired at $\frac{4}{10}$ths to $\frac{6}{10}$ths of a penny per mile. But one engineer thinks they do the work at half the price of horses. (See Bree's Railway Practice.) There is, however, considerable difficulty as to their working on so unsettled a foundation as an incipient sea-bank. Mr. George Stephenson says, "I stated last year it was impossible to use locomotive engines upon a temporary road with advantage, and I now repeat, it would be much dearer than horses: if you can get a mile or two of permanent road, I think they may be used, but it is madness to attempt it upon an embankment." He, however, remarks that they may be advantageous in point of time. Time also is a great matter in the execution of sea-bank work, since working months are nearly limited to those from the 1st of March to the 1st of November, and night-work is by some engineers reckoned double the price of day-work under favourable circumstances for the latter;

by others 25 per cent. more is allowed beyond ordinary labour.

The rapidity with which a bank could be built with tram-roads and horses would be limited by the number of tip-roads. At the early part of the work there may be six tipping-places, and 800 to 1000 cubic yards per day might then be delivered with a good arrangement of the work, but these tip-roads would gradually diminish to two, which would deliver only about 300 yards. Now, if 750 cubic yards could be accomplished as the average, a bank like that of the diagram would be erected within the working period of one year, viz. 1st March to 1st November: such a bank, from three to four miles long, and containing about 100,000 cubic yards per mile, might be completed in 200 days, or from 1st March to 1st of November, including some night-work in the summer, and working from each end of the bank.

But whichever mode is adopted of getting together the materials of a bank from a distance, the work will proceed with a certainty of effect, provided the materials are good, *i. e.* not light and loose enough to be much washed away by the action of the tide after deposition, and not open or porous enough to allow the water to percolate through, after the bank is finished.

In all such works, experience proves that everything depends on arrangement and method, but more particularly with tram-roads and waggons, since one con-

tractor will be ruined at the same rates by which another makes a fortune. Nothing, therefore, can be more important than the consideration of the best *methods* for conducting the work to avoid confusion, and so that each teamer *must* keep his time both going and coming; that no time may be lost; that each waggon should carry its proper load, and that no loitering should take place at one time, and hurrying at another. These are matters depending entirely on the skill of the managers and overseers; and the degree of that skill, and the constancy with which it is exercised, will make full 25 per cent. difference in the cost of the work. Some general views may, however, be mentioned,—such as that of waggons capable of being tipped on either side, instead of having to go to the head of the bank, by which means any number of loaded waggons might be employed and led to any required distance, unloaded and return by the same line of rail or tramway, and when sufficient earth was collected, the rails might be removed, and the earth shaped according to the sectional area previously determined on. Thus supposing the bank required to be that in the diagram, it would first be necessary to raise a bank to the height of spring tides, say 10 feet, and to place a single rail on that: this 10-feet bank would be raised in the same manner by unloading on each side from rails laid on the slob, during the tidal working hours, till there was

enough material collected to form such a bank; the material could then be piled up in proper form, rammed to consolidate as it arose, and the single rail placed at top of the 10-feet bank which might be built, with its centre upon the point c' in the diagram, and with say 9 inches to 1 foot slope on each side, which slope would be increasing continually by the unloading. When this was accomplished the workings could go on at all times of tide; no time would be lost, because the loaders would have another set of waggons filled by the time the empty ones came up, and the horses, with only the slightest contrivance imaginable, might be made to *push* the empty waggons back again for reloading, and for that purpose would only have to turn themselves round upon the tram-road. Thus arranged, one line only of rail would suffice, and but once moving of that. Any number of waggons might be used, and as soon as sufficient earth was collected, the bank might be "licked into shape." There might be some little labour in shaping the material for the rail-bank, so as to clear the rails laid on the slob itself, or a gravelled road thereon, at first; but this would not only be trifling, but highly beneficial in mixing and incorporating the material, and its consolidation by ramming would much assist in securing the *nucleus* of the bank, and rendering it not only firm and adhesive, but impervious to the soakage,—benefits far beyond the expense of shovelling up the material.

5th. The best *line of direction* for a sea-bank is not so often attended to as the matter deserves. This line should be considered with reference not only to the extent of the ground to be embanked, but also to its exposure with respect to the prevailing winds.

The best line of direction is not one at right angles with the prevailing winds and seas, but one rather in the same direction as these,—not a straight line, but one affording such curves as that the salient angles may protect the retiring lines,—not actually zig-zag, but with projecting elbows here and there, so placed as to embay the spaces between them. The benefits of these projections are considerable. They shelter, under some circumstances of wind and tide, very extensive reaches of bank to leeward of them, and in other cases they break and divert waves that would otherwise rake the bank for miles. They act as jetties also, and tend to accelerate, if they do not actually cause, the accumulation of silt and mud in the bight to leeward of them, and so not only strengthen the bank, but also prepare for another embankment outside of the first. Care must however be taken to enable these advanced guards to sustain the rudest shocks of the ocean, and, with this view, they must be *well* covered with stone over the whole of their height above tide.

The position and distance of these points must depend on the general form of the shore and on the form of the line chosen for the embankment, but it

would be well to place them upon any rocky or gravelly points that may exist on, or near, the line, or even any little mounds that may occur on the line, if of sound materials, but also so as to present one of their projecting sides to the most prevalent wind and sea, and so that it may throw off to seaward any wave striking that side.

The distance of such points may be from one to two furlongs, and in the case of bays between, they may be more distant, even to a mile. The bank in the intermediate spaces between these points had better be rather curved than straight, and the curves had better be rather inward towards the land than outward towards the sea,—because the power of the wave will be diminished by the inlet or bay thus made, and it will have a tendency to fill up and strengthen the bank.

In choosing a site for a sea-bank, care should also be taken to avoid those spots which are exposed to any great current or rush of tidal or land-flood waters against the bank, since the force of such waters may be so great as inevitably to overcome the resistance of almost any bank. In estuaries or inlets where the entrance is wide but suddenly narrows, these currents are often very strong,—the tide comes up with an "eager" or "bore" as it is variously called, *i.e.* a wave of several feet in height,—as in the Severn for instance, which scarcely any bank could receive "full on" without destruction, although it might pass innoxious from

end to end *along the line* of bank. Sometimes also, the most tempting land-locked situations are liable to this objection, and where it seems only requisite to join two opposite projecting points by a bank, in order to gain a large extent of land, and yet such a bank may be almost impracticable by reason of the strong current with which the tide sets in against it. On the other hand, there may be very eligible situations for a sea-bank, even in such estuaries as are filled by a rapid tidal current, because there are often in such estuaries projecting points of land which break the force of the current, and in the bight of which the tidal rise is almost tranquil. These are therefore points of the utmost importance to be attended to in the choice of an eligible site, or line, of intended sea-bank.

6th. But the most essential consideration in the line of a sea-bank is its situation with reference to low-water mark, since on that depends the drainage of the land embanked;—and unless *that is perfect*, its reclamation and cultivation are hopeless. This drainage is to be effected by means of sluices, with valves to close with the tide, and to open by the pressure of the land waters, and of these we shall treat further on, under the specific head of Drainage.

The bank, therefore, must be placed sufficiently above the tide at ordinary low water to admit of the sluices remaining open as nearly six hours as possible, and in general for four hours at least. If placed *at*

low-water mark, the return tide would evidently shut the sluice valve, or door, almost as soon as it was opened by the tide receding, although so long as the weight of water inside the sluice is greater than that outside of it, so long will the sluice remain open. When placed so low, however, the run is stopped whenever the tide does not recede so much as usual, which often happens when the wind keeps up the water, and also in neaps. Therefore the sluice must be placed, as nearly as circumstances will admit, so far above the low water of spring tides as will allow it to have six hours' run between tide and tide, beginning to run at half-tide of ebb, and continuing to half-tide of flood.

But the sill of the sluice should be at least 2 feet below the level of the land, therefore the proper height of the foot of the bank above low-water mark is 4 feet at least. Most speculators will, however, carry their line of bank to within 2 feet of the low-water level; but this is imprudent and injudicious, as the greatest fault of an intake is being too low with reference to the tide, and the more especially when it is flat as well as low, in which case its drainage is difficult and expensive, and, however good the soil, its cultivation must be imperfect without the expense of machine drainage, in addition to what natural drainage can be obtained. We conclude, therefore, that the most eligible situation for a bank is such as will allow

of about 2 feet from the sill of the sluice to dead low water, that sill being placed 2 feet below the general level of the land, *i. e.* the land being 4 feet above low-water level; but this must depend on many circumstances, amongst which the quantity of water intended to stand inside the intake, or what is usually termed "the fleet," must be taken into the account; and if all cannot be drained, it will be important to determine how much beforehand, and to place the bank accordingly. Thus, for instance, should the proposed intake consist of 1000 acres, and should the chief part, say 700 acres, of its surface, be 4 feet above the dead low water, it would be sufficient; although 200 acres more might not be above 3 feet higher than low water, and even 100 acres either not above 1 foot higher, or never ebbing dry, since these lower levels may either remain as fleets (lakes), or, if worth while, be drained by steam.

II. THE ELIGIBILITY OF A SUBJECT FOR EMBANKING.

The *eligibility* of any shore, slob, ooze, or salts,—as the space covered by the sea at high tide and ebbing dry is variously called in different localities,—may be partly inferred from the preceding observations, but there are also various other points to be specially considered, amongst which the following may be regarded as the most essential, viz.

(*a.*) *Its height of base above the tide.*—This is important for several reasons, but chiefly on account of its drainage to seaward; for, as has already been noticed, unless there is height enough above ordinary or medium low water to admit of the sluices running from four to six hours between tide and tide, no sufficient natural drainage can be obtained, and it may be necessary to resort to the expensive means of steam drainage, and even that may not be effective in all cases, *i. e.* cases in which the land waters come down very suddenly.

In Essex, no intake, as the embanked grounds are

there called, is ever attempted of ooze or mud overflowed by every tide. It is only the saltings which are considered fit subjects for that speculation, and these are only covered by spring tides. The banks, or, as there termed, sea-walls, are therefore on ground generally 5 or 6 feet above low-water level, and the sea-walls seldom exceed 6 or 8 feet in height above their seat. Still it is very possible to embank and drain lower slobs than these, but the difficulties are proportionate, and on the whole it must be concluded, that any slob of less height than that which admits of four to six hours' run, unless of extreme fertility to afford steam drainage, is not eligible for embankment, as besides the drainage, the lowness of the ground must be compensated by additional height of bank, and the hazard, and the expense of security against that hazard, are thereby increased. Still, land-locked and sheltered banks may securely admit of a great height of bank if made strong enough, but then the expense *may be* augmented beyond the ultimate value of the land to be gained. There is also another point, in which the height above tide is of consequence, viz. that in low cases the soakage from sea to land is greatest, and the hazard of the bank blowing up more imminent. Besides, low slobs have seldom attained to those qualities of soil which are essential to fertility, and which time alone can give. There is yet another objection to low intakes, viz. that they contain so much salt from the constant presence

of the tide, that they are a long time in becoming sufficiently freshened for cultivation, and that time is prolonged in proportion to the tenacity of the soil.

(*b.*) In the second place, eligibility much depends on the nature of the soil of the space proposed to be embanked, which must in particular be carefully considered. In Essex, where the banks are placed so high, the soil is particularly favourable, both to sustain embankments, and as a material for making them, and is called *Marsh clay*, being probably the *débris* of the London clay, macerated by diluvial action. In the Isle of Ely and Lincolnshire the soil is *silt* or a sea-sand, ponderous from the smallness of its grains or particles, and somewhat cohesive from that cause, or from the argillaceous matter mixed with it. Here also few embankments are less than 5 feet above low water. The best and earliest indication when a marine soil has become fit to embank is the growth of *samphire*, which demonstrates its stability and permanence of position, and is the forerunner of the marine grasses, so healthy for sheep, which are largely fed on the very extensive saltings of Essex, care being taken at first to drive them off as the tides put on, though they soon learn to come off themselves, before the filling of the creeks prevents their escape.

The best soil for an intake, therefore, is that clayey earth whereon sufficient marine herbage grows to

afford sheep-feed of some value, and this will be above the level of ordinary tides.

The next best is silty earth, with sheep-feed like that already mentioned as found on the Lincolnshire coast.

The third is mud-banks with samphire, over which the spring tides always flow.

The fourth is mud, over which the tide always flows more or less, and this is eligible in proportion to its clayey matter.

The fifth is what is called sheer sand, which is almost barren, except as to a few plants, such as the *eringo*, the *sand-rush*, &c., but sometimes even this sand is rendered to a certain degree fertile by the calcareous matter of comminuted shells, or may be rendered fertile by raising on its surface the marly substance sometimes found beneath.

A sixth class may be designated in those sandy and shingly dunes, which continue for ages bare of vegetation, and are only worth embanking on account of local value; and these must be deeply covered with mould to enable them to grow anything. There is a breadth of several miles of such sands and shingle between Lydd and Dungeness on the Kentish coast, and much also south-west of Hunston in Norfolk, and about Yarmouth.

In our judgment on the all-important subject of soil, we are not, however, to be misled by the black

and stinking deposit of the sea amongst sandy particles,—not to mistake the mere decay of marine vegetation for inexhaustible fertility or rich manure. Such matter soon dries into a *caput mortuum*, and little but a white sand remains. To secure permanent or high fertility, there must be sufficient quantity of argillaceous matter to render the deposit somewhat slippery under foot when in a moist state, and if some shells are seen, so much the better.

A chemical analysis of the soil would be highly interesting, and by it the proportion of *humus* in the soil, as represented by the animal and vegetable matter, would probably be great; but the proportion of argillaceous matter, with reference to its staple and powers of fertility, would be but vaguely expressed by the proportion of *alumina* or pure clay thus found, since that is a substance scarcely existing but in chemistry, and in nature is so universally mixed and amalgamated with silicious and other matter, as to lead to the conclusion that it is not the quantity of this constituent, so much as the nature and mode of its admixture with other constituents, which give staple and fertility to a soil. Liebig's (or rather Sprengel's) analysis of soils gives an average of 0·908 per cent. of *alumina* in 18 cases of light sandy soils, and an average of 2·559 per cent. to 8 cases of poor infertile soils, one of which was 4·200 per cent. Also an average of 1·624 per cent. of *alumina* to 8 cases

of good loamy soil, the highest being 5·128 and the lowest 0·650 per cent. One of these was sea-shore land, and had 4·941 per cent. of *alumina*. Also an average of 4·383 per cent. of *alumina* to 12 cases of very good land, and 12·700 per cent. to 3 cases of remarkably fine wheat land, though not very heavy, whilst 4 cases designated as *strong land*, or heavy land, contained an average of only 1·969 per cent. of *alumina*. Though the infertile soils here show the smallest quantities of *alumina*, and the good wheat soils the largest, yet in other respects the proportions of *alumina* are not such as to afford a safe or sufficiently intelligible criterion of staple and fertility in that particular. A specimen of soil from Weston, Hunts, on the heavy clunch clay, the coldest and heaviest of all soils, analyzed at the Board of Economic Geology, Craig's Court, (now Jermyn Street,) London, gave 9·7 "alumina or *clay earth*," which seems a clearer mode of expression than by *alumina*, meaning pure clay; and any one accustomed to judge of the acreable produce of soils under fair farming, and thence of their rental value, would prefer an analysis which gave the argillaceous and silicious matter generally, the other minor ingredients of soils being as minutely expressed as chemistry will give, although, after all, the outward and visible signs are quite sufficient to enable those who have long made it their study and practice, to form a correct judgment on

the capabilities of soils, which depend on many circumstances besides the chemical ingredients—as situation, aspect, subsoil, drainage, condition, and the like: still it is thought that an analysis of soils proposed to be embanked would be very desirable. The late Rev. Mr. Rham quotes as rich alluvial soils three instances containing respectively 81, 79, and 74 per cent. of clay, 10, 10, and 6 per cent. of sand, and 11½, 8½, and 6½ of humus. The German chemists consider soils as clayey when containing about 50 per cent. argillaceous matter, loamy when 30 to 50 per cent., sandy when 10 per cent. Soils to be fertile should also contain at least 5 per cent. humus and 5 per cent. calcareous matter.

In Essex, where the marsh clay is very tenacious, several years must elapse before the salt is sufficiently carried off to admit of cultivation, but it happens sooner in sandy soils. The fertility of the soils of intakes is, however, partly due to the saline as well as to the animal matter which they contain. It is only the excess of saline particles that is injurious to vegetation, as may be proved on any land where salt will destroy the bad grasses, but, when sufficiently diluted by the rains, will encourage the succession of good grasses.

One may judge of what the sea-mud will come to when laid dry, by observation of the neighbouring shores. If they are argillaceous, so will be the soil

of the intake; if silicious, sand will predominate, since these mud-banks are but the detritus of those shores altered by the sea and its contents.

The embanker may, however, always test the time it will take to freshen and to admit the growth of clover by experiments on the soil from different spots, brought into a garden and surrounded with frames, to separate it from the other soils. It must, moreover, be remarked that soils in their crude state undergo great changes by admixture and thorough amalgamation of their particles; their productiveness is so dependent on this, that we regard *harrowing* as one of the most important operations in the culture of soils.

Shells mixed in fragments, or in layers, are always a good sign, and denote fertility. There are also often to be found patches of calcareous clay amidst sandy shores, though covered with silicious matter, and by raising such upon the surface the fertility may be greatly increased.

It may also be well for an intake to include some acres of beach or shingle, or gravel, as that material may prove highly useful for making or repairing roads, &c., or even for draining.

(*c.*) Another point of eligibility is the degree of shelter from prevailing winds which the position of a bank may afford, and consequently protection from seas driven up by those winds. This point is important,

inasmuch as with a long sea-reach having full play against a sea-bank which stands broadside to the prevailing winds, it is so continually flogged and battered by the waves, that nothing but an expense disproportioned to the benefits can sustain the banks. It therefore becomes necessary to look carefully to this point of shelter, as one of eligibility, and for some headland or some rock, some spit of land or bank of sand, which may either act as a shelter from the winds, or as a breakwater from the heavy seas, since the more sheltered and land-locked is the site of any intake, the more eligible and secure will be its position, the more valuable its property, and the less expensive the maintenance of the sea-defences; and moreover it is in such situations, as in bays, coves, and inlets, that the richest and best diluvial and alluvial deposits of soil are most usually found.

(*d.*) It is also a point of eligibility that the proposed intake should have some difference of level,—should be somewhat of an inclined plane, and somewhat varied in surface, into table-lands and channels; so that the waters falling on its surface may have free discharge into those lows or *fleets* which usually occupy a considerable portion of the surface of marsh lands, without which a good and sufficient drainage of the lands for the purposes of cultivation is extremely difficult, as a dead flat is apt to retain the surface water too long for vegetation, even when well

provided with grips, or surface drains, to carry it off.

(*e*.) But though some main channels and deviations from dead level are desirable, it is also good that the surface of the intake should not be cut up by a multitude of rills and gutters, which may cause great expense, not only in crossing them by the proposed embankment, but also after its completion, in filling up and levelling them for the purpose of cultivation. It happens generally, that the higher the lands to be embanked, the more they are intersected by rills and creeks, and this is a common drawback on that point of eligibility which relates to height above the tide. The lower levels of the shore or slobs are, on the contrary, almost free from this objection, and when in other respects eligible, these lower levels present tempting subjects of embankment.

(*f*.) Another consideration of no small account is, that the subject affords a good and solid foundation for a sea-bank, such as will bear the weight and stand the test of the rudest shocks of the sea,—such as will neither slip nor sink, nor admit of a dangerous degree of soakage,—such, in short, as will sustain the bank, and remain firm under all circumstances,—to insure which trials should be made along the whole line of intended embankment; and in case of any loose, soft places being discovered, such as often exist

in low slobs, they must be carefully filled in with sound material before the bank is set thereon.

(*g.*) Climate is also a momentous consideration. It happens that on the eastern shores of England much less rain falls than on the western side or mountainous parts of the island, and on these eastern shores are the greatest extent of marshes. A dry climate renders less necessary the means of drainage, whilst a wet climate almost baffles every means of drainage that can be adopted upon very low flat lands, with but a slight fall to seaward; hence in climates where much wet falls, as amongst mountains, the eligibility of any subject for an intake will be proportioned to its capability of drainage. Still it must be recollected, that this objection only involves the question of a greater number of sluices, which are no great expense, and may be aided by steam.

(*h.*) In a mountainous country, or even such a one as presents a considerable slope towards the sea, the inland waters may be so considerable as to require great expense in conducting them to sea, clear of the intake, by means of *catchwater drains* intercepting those upland waters, and carrying them out to sea, independent of the waters of the intake; viz. those of downfall upon it, or springs rising within it: hence such intakes as have the smallest quantity of upland waters to provide for, are the most eligible subjects.

(*i.*) Yet, although a due supply of fresh water be one of the most essential features of an intake, and this supply from natural springs rising within it be very desirable, still too many strong springs rising in an intake may detract from its eligibility, by rendering it necessary to sluice out so much water. Therefore such springs should be sought for, previous to determining on the embankment, and their discharge provided for.

(*k.*) When vast accumulations of infertile gravelly detritus are brought down by rapid rivers, and deposited on the site of an intake, it is a mark of ineligibility; inasmuch as the courses of those rivers when embanked are apt to fill up with gravelly *débris*, and either to overtop or burst the banks, thus causing floods at least, if not invasions of fertile lands by a covering of infertile soil. The only caution against this defect is a wide opening between the river banks; but even this often avails but little, unless the river is powerful enough to cut its way to sea through its own deposits, or be assisted by the steam-dredge—a powerful machine too little patronized.

III. OF THE DRAINAGE OF EMBANKED LANDS.

The modes of *drainage* of an intake have been touched upon, but require further explanation. As already mentioned, the usual discharge of the land waters to seaward is by sluices placed through the bank from the landward to the seaward side. Such sluices are most common in Essex, where they are constructed of 2 or 3 inch elm plank, secured by oak land ties, and piles; the run or width of the water-way is seldom so much as 3 feet, often no more than 18 inches, and about 2 feet in height. They have what are called tankard-lid doors, working on a bar with rounded ends in a cheek, attached to each side of the sea end of the "gutter," as it is there called; the lid is set a little springing, and if necessary is loaded, and sometimes fitted with copper or leather at the edges. Three feet is however rather too wide for the tankard-lid, and small pointed doors have perhaps answered best for such an opening. The elm timber is found to

last a great many years in constant wet, and its renewal is more generally rendered necessary by the sea-worm, or *teredo*, than by natural decay. Foreign deal is also found to answer well when always wet.

An iron syphon, carrying the land waters *over* the bank or wall to sea, was erected at Tollesbury in Essex, but was soon discontinued.

Iron cylindrical tubes have been adopted, but it is thought not judiciously, unless they are always to run full; since, with a small run of water, it is evident that the flat base of a parallelogram will carry more water than the curve of a cylindrical tube, although the circle will carry more water than a rectangle having the same periphery.

The best level at which to place a sluice to afford the longest run is probably between the mid-tide level and the low-water level of neaps, because although the run from mid ebb to mid flow is near the maximum of six hours' time of running, yet in case of there being any water in the intake above that line, its weight will push its way for some minutes, perhaps an hour, before mid ebb, and for the same time after mid flow, making the run seven hours. If placed lower, the valve or door of the gutter or sluice would be shut sooner by return of tide; and if placed higher, it would run longer, but take off less of the land water. A *flood sluice* has been found useful, so placed that it shall take off the first few inches in depth of any more than

an ordinary accession of land waters, the other and lower main sluices working out the remainder.

The position of these sluices must be well out to sea, *i. e.* with as little impediment as possible and with a channel cut from the sluice to low water, not discharging into side streams which will override and stop them whenever a flood takes place, at the very time their free discharge is most requisite. But on very flat shores some difficulty may exist as to keeping open the sluice doors, by reason of silt and shingle thrown in by the sea against them, if placed near to low-water mark. For this there is no remedy but either continuing the sluice to seaward, or occasionally clearing it, or helping it to clear itself.

The requisite number of these sluices must be matter of experience after the bank is completed, since no one can tell what springs may rise in the intake after the tide is shut out, nor what quantities of water may come from the high lands adjoining, besides what falls on the intake itself. A very considerable provision must certainly be made for the discharge of these waters, and many sluices must be laid down. In Essex, where the marshes are flat, but with little water from the high lands, one sluice with a 2-feet or 30-inch run suffices for some hundreds of acres; but on that eastern coast there is little rain compared with other coasts, and in cases where much rain falls on a flat surface, every 100 acres will probably require a sluice or

gutter with a 30-inch run. It will however be matter for consideration, whether one or more large sluices with pointed doors, and with an 8 or 10 or more feet run at once, will not be preferable to so many small sluices. The expense of these large sluices, and also their danger from the sea, is against them; but the consideration of their stream being powerful enough to keep open the channel to sea, and the necessity being obviated of incurring the danger of opening the bank to put down or repair smaller sluices,—that operation requiring great care in "ripping" one side of the bank at a time,—is in their favour. Long days and calm weather should be chosen for placing these sluices. Some, however, place them at the building of the bank. Should all this be insufficient to keep down the waters over the intake to the depth of 18 or 24 inches below the surface, *machine drainage* must be employed, and this is now so well effected by steam, at an expense of between 1*s*. and 1*s*. 6*d*. per acre per annum, exclusive of first cost of machinery, that in the Fens, to drain naturally to some extent, and to finish by the ready and certain means of steam, is considered preferable to an entire natural drainage with its uncertainties. No objection therefore exists to steam machinery for draining, but its expense, and that is next to nothing if the land be fertile, since the increased value of produce will be many times its cost. In such cases it is probable that every horse-power

would drain at least 150 to 200 acres, every available natural drainage being employed, since, on the average of twenty-five steam engines, in the Fens, each horse-power drains 125 acres without any natural outfall. This steam drainage, wherever requisite, should be paid for by the occupiers under an acre tax.

But the enterprising speculators of the present day have proposed embankments where the low water is 10 to 12 feet deep, it being designed to build a bank and to pump out this depth of water from the inside of the bank by means of steam machinery. This is proposed to be done in imitation of what takes place in Holland, where the *Polders*, as they are called, consist of vast lakes laid dry by artificial means, and the rich diluvial soil highly cultivated. A very extensive instance of this kind of enterprise is now proceeding at Haarlem, where 70,000 acres are in the act of being drained by steam-power, for the purpose of cultivating its rich diluvial soil. But enterprises of this magnitude are not within our present contemplation, nor shall we attempt to determine whether any differences of climate or of soil account for such attempts not having hitherto been made in the British Isles, whilst they have been profitably made in Holland. We may, however, with certainty conclude that neither English skill, English enterprise, nor English capital, has been deficient. And whether any land can be so valuable when obtained, especially under the present

state and prospects of husbandry, as to justify such expensive modes of obtaining it, is a question not easily solved but by the result of "experience and the evidence of facts."

But whatever may be the means by which drainage can be effected, it will at least be well to obtain as much of natural drainage as may conveniently be had, not only as the least expensive, but also as the most constant and effectual. Sluices, as has been said before, are the most simple means of this natural drainage, and these will run a shorter or longer time, according to the height of their sill above low-water level,—to the degree of ebb of tide,—and to the height of the water standing upon the sill of the sluice. Thus, the sills of some sluices laid down have been but 6 to 12 inches above low-water mark, according as the tide ebbs out more or less at springs or neaps, when not acted on by winds and otherwise kept up. These sluices at the period of a good ebb, and having 12 inches of water on their sills, will run four hours. They would therefore run dry if the tide ebbed 12 inches lower, so that it appears that if the sill of a sluice has 2 feet fall to low water of springs, it will generally run six hours when the tide is not kept up by winds,—and when there is much pressure of water on the inside, it will run nearly seven or eight hours. But as the waters of an intake should never stand less than 18 inches below the lowest level of the land, (except where lakes

must remain,) and as 6 inches should be allowed for the water to stand usually or often in wet times on the sill of a sluice, that sill should not be placed at less than 2 feet below the general level of the land where the bank is placed; and as there ought to be at least 2 feet fall from the sill of the sluice to the low water of springs, it follows that the line of bank should at its foot be at least 4 feet above low-water mark at springs, as above stated, and it must depend upon the quantity of water to be discharged, what number of sluices should be put down, and the width of their several runs.

On this subject of drainage, we may add, that it is absolutely necessary to construct *catchwater drains* for the purpose of conveying the external waters to a distinct and separate outfall, either into adjacent side streams, or discharging by drains and sluices distinct from those of the waters of an intake itself; for otherwise the highland waters will so suddenly flood the flat surface of the intake in wet weather, as to render its drainage too difficult to be accomplished in time for vegetation, and too expensive to answer the purpose.

Thus a fivefold mode of general drainage may be necessary; namely, a drainage by *catchwater*, a drainage by *sluices*, and a drainage by *steam;* but besides these it will be necessary to intersect the surface of the intake with cuts conveying the waters to their outfall, these dykes being also that kind of waterfence called *marsh ditches*, and also to convey the

waters of all low spots into these cuts, by means of surface drains called "*grips*," which should be ramified more or less thickly over the whole surface according to its flatness, and the drainage of the intake will be then complete.

IV. OF THE RECLAMATION OF EMBANKED LANDS.

The various modes by which embanked lands may best be *reclaimed*, and brought into a state of cultivation, will of course depend on many circumstances, of which the nature of the soil will be one of the principal, if not the chief consideration. We are therefore now to contemplate an intake securely and completely embanked, together with sluices of sufficient capacity to take off the water falling or coming from other lands on the surface of the intake, and these sluices having a sufficient run to seaward, to carry off those waters down to 18 inches below the general level of the surface of the intake, in sufficient time to prevent injury to vegetation. These are essential conditions, on which alone the work of reclamation can be commenced with any hope of success, and these conditions being strictly fulfilled, we may proceed to agricultural operations according to the nature of the soil, which may be classed into *clayey*, *sandy*, and *loamy*, each of which will require a somewhat different treatment in some

respects, though in other matters they may be treated in the same manner, or nearly so; thus, for instance, in the first agricultural operation,—viz. that of enabling the soil, which has so lately been supersaturated with salt water, with all its chemical combinations, to part with so much of its saline and other particles as may be in excess for the purpose of vegetation; or, in other words, to *freshen* the soil sufficiently for land plants to thrive upon it: the process will be the same upon all these soils, and this process consists in forming a series of surface drains, grips, or channels, by which the downfall and other waters may run off, carrying with them such portion of the saline and other particles as they may have been enabled to dissolve, and take up or absorb.

But such channels and drains are to be made, not only with the view of freshening the soil, but also in such manner as to answer the ulterior purposes of fences, and of drains timely to carry off the surface waters.

The fences of an intake are usually marsh ditches or dykes, standing wide and deep enough of water or mud to prevent cattle attempting to cross them, and an intake seldom admits of any other description of fence. Such water-fences and drains must, in the first place, be drawn all around the intake, *i. e.* from the sluices by which the water is to escape along the land side of the sea-bank or wall, and

along the edge of the higher lands of the adjoining country. The proper dimensions of such fences are 10 feet wide at top, 5 feet wide at bottom, and 5 feet deep, the water always standing 3 feet 6 inches in depth, which will be 18 inches below soil; and the surface of the water will be then level with the sill of the sluice, or near thereto,—since, as the sluices will be in the lowest parts, some water will probably always stand on them, unless the intake be on a dead level, which is not desirable. By the same rule, should any inequalities of level exist on the surface of the intake, the dykes or ditches forming the water-fences must be dug accordingly, deeper than 5 feet and wider than 10 feet, so as to have nearly the same *level of bottom*, and the same depth of water, throughout the *level*, as the intake will now be denominated. Having surrounded the level with these fences and drains, the next operation is to divide it into marshes of such convenient size as may be judged most judicious; and this size will be partly governed by the soil, clayey soils parting with their salt most reluctantly, and sandy soils most easily. It will also be more strictly governed by the size most convenient for occupation in the particular locality, and also by the desire to save expenses; but in general sandy marshes may be considerably larger than other soils, and there may even be some advantages in leaving the interior of the

level for some time without subdivision, since it will be by no means wise to hasten the process of freshening by any kind of washing or sudden saturation, but, on the contrary, to allow a considerable period of time to elapse before any thought of cultivation is entertained, and during that period to allow the level to remain sodden, only leading the surface waters away gently into the circular dykes already described, so as to prevent any pools of stagnant water; and it may be very judicious to fill up the nearest of such hollows or "pans," as they are called, with the stuff out of the circular dyke. This soddening, or stagnation of the soil in a watery state, is considerably more applicable to sandy soils, and to such of those as have before embankment been covered by every tide, than to clayey soils, and will be quite unnecessary in such high fringes or salts as have only been occasionally covered by the tide. But the benefits of allowing the soil to remain for a length of time under the influence of stagnant fresh water are great, since it affords time for the decomposition of such animal and vegetable matter as the sea may have deposited in it,—macerates and dissolves the calcareous, shelly, and other such matter, and even reduces the silicious matter into a state of subdivision resembling clay; and it amalgamates all those heterogeneous particles, takes off their crudities, promotes or prepares them

for chemical combination, and reduces them to a state fit for the purposes of fresh-water vegetation. But such effects as these are not likely to happen by the too powerful action of water that might, and probably would, wash away the fertile or fertilizing particles, and reduce the soil to a state of infertile sheer sand, or sharp sand, and prove most injurious to future fertility of the level; we therefore disapprove any attempt at suddenly freshening the soil, and consider that even the soddening process recommended should be conducted with great care and caution, always gradually, but neither allowing the water to remain too copiously nor too long, nor suffering it to run off too quickly; for this purpose, therefore, cuts or channels should be made from the lowest spots of the level into the circular dyke, so that no water should remain absolutely stagnant if it could be got off, but that at the same time it should only be drawn off gradually: thus, supposing the whole level could be gripped, or channelled from the pans to the circular dyke, within the first year after shutting out the sea, and this was done only 12 inches deep, these grips should be allowed to remain at that depth a full summer and winter at least, before deepening them another 6 inches, bringing them to the ultimate depth of 18 inches; gradual freshening and maceration being essential to future fertility, and this requiring a longer time in propor-

tion to the quantity of saline matter, and the crude state of that matter, with reference to vegetation, at the period of its embankment.

Thus we have brought the level into this state; viz., it has a marsh dyke or water-fence surrounding it, and very numerous grips throughout its surface, leading the waters into the marsh dykes to the depth of 18 inches below the general surface, but of course lower where elevation of surface occurs. In forming the principal grips, care should be taken that they be cut in such places as to fall in with, and promote, the ulterior design of laying out the level into conveniently sized marshes; and it will also be proper to consider which way the ridges and furrows will lie, in case of these marshes being ploughed, and to lay the grips parallel thereto if possible, recollecting that the nearer the ridges lie to north and south the better.

The depth of the soil, we may now suppose, has been somewhat increased by the soil arising from the grips being spread about. By this time several brackish plants, partly of a maritime, and partly of fresh-water nature, will have appeared, and partially covered the surface in places: these may be grazed to advantage, and as the surface soil freshens, it may be harrowed, and Dutch clover and ray grass may be sown and rolled in, wherever the absence of other plants may allow of them; first, however, bestowing

but a small quantity of seed by way of experiment, and increasing this as success may encourage from time to time. In a period varying from three to seven years, according to the tenacity of the soil, and its height above the tide, the level will be fit to bear corn and pulse. If its surface be coarse and uneven, and its soil tenacious and stubborn, or what is called marsh clay, it may be judicious to dig it over and level it at the same time, preserving however the grips already dug; taking in the first instance a crop of coleseed (rape), which might judiciously constitute the first crop, and may either be saved for seed or fed off, and be succeeded in either case by oats, then beans, and then wheat; but even after the digging of such soils, they will require much tillage, so as to thoroughly mix and pulverize them, and the bean crop should be repeatedly well hoed and weeded. With good treatment, however, such soils bear heavy crops of wheat and beans in succession, and when some degree of exhaustion calls for a relaxation of cropping, the course of fallow, oats, clover, wheat, beans, will give all the produce that can reasonably be expected from any land; the crops very commonly grown on good soils of this kind being 8 to 10 quarters per acre of oats, 4 to 6 quarters per acre of wheat, and about the same of beans. This produce, however, must not be reckoned on as over the whole surface ploughed

and sown with these crops; for at least one-eighth to one-fifth thereof will consist of "lows," "rills," and "pans," where the clayey soil will be still too crude, too salt, too wet, or too stubborn, to bear perhaps any crop, or at most but one-fourth of what is borne by the best parts. This drawback, together with the expenses of cultivating this description of land, soon points out that grass, not tillage, is its most profitable ultimate destination, and accordingly it is found expedient to prepare it for the true and legitimate purpose of an intake, viz. grazing. But we must not fall into the error that because this is the last, it may also be the first, destination of the level, a course of tillage being requisite for a time upon all the *argillaceous soils*, in order to mix and incorporate them, and to pulverize the soil, so as to bring it into a fit state for the production of the better kinds of grasses; otherwise the coarser will predominate, and the value of the ground be much deteriorated. The necessity of this course of tillage is demonstrated on a piece of silty loam-salts, near Fossdyke, in Lincolnshire, which the late Sir Joseph Banks, with his habitual consideration for the public good, ordered to be left untouched, in the state in which the whole intake was when embanked, and after a lapse of nearly thirty years the maritime salt plants still remain, and the land plants but feebly strive to establish themselves. In pro-

portion, therefore, as the course of tillage is perfect without being continued to exhaustion, and as the levelling and surface draining are well performed, so will be the productive value of the grazing marsh which succeeds the tillage. Nor are these operations sufficient in stiff clayey soils; such will require to have their tenacity subdued or lessened, their working rendered easier, and their pulverization or admixture of parts more effectual, by the application of chalk rubbish, *i. e.* soft chalk, to the land, after the rate of at least ten tumbril cart-loads per acre, which will usually cost about ten shillings per cart, including carriage. This supply of calcareous matter will also act as a manure, and will not only increase the quantity of wheat, but also tend much to improve its quality, to stiffen its straw, so as to prevent or check its lodging, and the consequent deterioration of the grain. In these various ways, an expense of £5 per acre thus incurred will soon be repaid, whilst its beneficial effects on the soil will last at least twenty years even under a succession of cropping, but in grass would be permanent.

The more silicious soils, whether sandy or loamy, require less chalk, if any; and as their texture is apt to be rather too open than too close, lime is often much better adapted to them, if any manure be at all needful, since an intake of soils of this kind generally abounds with shelly fragments, enough to

supply the requisite quantity of calcareous matter. It may, however, be well worthy of consideration, whether a supply of lime would not be advantageous in setting to work that calcareous matter, and consolidating the texture of the soil.

There are several reasons why any course of tillage should not continue long upon an intake level, one amongst which is, that even under the misfortune of a breach of bank but little harm ensues to grass marshes, provided the tidal waters be again excluded within a few months, because the saline particles, not being in excess, are rather fertilizing than otherwise; but the chief reason is, because the intake cannot advantageously continue many years without suitable farm-buildings, which require a great outlay of capital without adequate return, since a more profitable appropriation of the land can be made without them; and besides, if the natural fertility of these lands is exhausted by a succession of corn crops, it will be vain to look for their becoming rich grass lands afterwards. The period of tillage, therefore, should be limited to such a space of time as may be sufficient, according to the nature of the soil, to bring it into a fit state for the best grasses to grow to perfection. This, on *stiff clay* lands, may be reckoned as 1, oats,—2, beans,—3, wheat,—4, beans,—5, wheat,—6, clean fallow,—7, oats; and lay this crop down with grass seeds, or what would be

better, either sow it down on the fallow with grass seeds, and about half a seeding of coleseed, feeding off the same in a dry part of October, or otherwise inoculate it with the roots of sward from some good grass marshes in the neighbourhood,—a process in which a machine is used, constructed for the purpose of shaking apart, or otherwise separating, the grass roots, and then sowing them on the ground by hand, and rolling them down, by which means a good sward is obtained much sooner than by seeds alone, though both should be resorted to.

But on the good *silty loams* of an intake, a different mode and duration of cropping may be adopted. Upon such lands, along the coasts of Norfolk and Lincolnshire, the usual course of cropping is 1, beans,—2, oats, —3, wheat, and they get better wheat after the oats than before, the straw being less bulky and less liable to "go down." But even in the case of such soils, if the argillaceous particles are in such abundance as to produce an unctuous texture or slipperiness under the feet when rather wet, they may judiciously be subjected to the rotation prescribed for clays, and treated similarly.

There must, however, be a very great difference of treatment with regard to those light, loose, sandy soils, of which some spots of the intake level will be found to consist, when taken from the low slobs of a sandy shore which has been covered by every tide. Such

loose sands, if *blowing when dry*, should be fixed as soon as possible by any feedable grass, that can be made to grow upon them, until a better sward can be produced. On such loose spots the *agrostis maritima* or *sea-side fiorin* has grown luxuriantly, especially when the *stolones* have been planted in a wet sod of bog turf, and that trodden into the sand. The shoots from these sets have been extremely vigorous, the cattle have sought and eaten them with avidity, and the treading thus induced has fixed the sand, whilst the droppings of the cattle, containing the undigested seeds of other grasses, have soon brought up a good sward wherever the drainage was sufficient for its establishment.

In such cases of loose sand, no tillage need to be, or perhaps can judiciously be, contemplated. Such soils are already sufficiently open to part with their excess of saline particles, and are generally sufficiently homogeneous not to require admixture by stirring, unless it be by harrows on the surface, to let in the Dutch clover seeds that may with propriety be sown thereon, when that brought by cattle shall be permanent enough to show an aptitude in the soil for that plant. These seeds, after being thus sown in moist still weather, should be rolled down, and if the soil has been well drained and freshened, it is more than probable that a good grazing marsh will be established, at less expense, and in less time, than could be effected by any other means;

since if the clover thrives, the cattle will lie so constantly on those spots as to enrich them more than any others.

The cultivation of rape for seed has been much relied upon with reference to these newly acquired lands, as the first crop thereon; but it should be recollected that the price of this seed is much reduced by importation; that such crops on new grounds generally come very unequal; that it is a crop very liable to injury by frosts on low grounds; that the climate of this country does not admit of any good chance of saving any very *large* breadth of this crop; that the straw is valueless; and that it occupies the ground for two years, although on this latter point there is a remedy in a species of rape formerly grown on the Lincolnshire Wolds, which ripened the same year as sown. The merits of rape, however, are that it will grow on crude and not perfectly prepared land, and costs little for seeding, and if the land be clean, is not a bad forerunner of wheat.

Mustard is another of those crops, which, being somewhat more valuable than common corn crops, are reckoned on as a means of returning some portion of the great outlay incurred upon an intake. The brown mustard taints the land worse than any weed, as is instanced in Canvey Island, Essex, where it is harvested with the beans, and is sometimes the best crop of the two. The white mustard has not the property

of lying in the land, but requires a finer tilth and better soil than the brown sort, and an intake would require a lapse of time to prepare it for this crop, or for any other of the seed crops usually cultivated as extra valuable on the rich soils of Essex or Kent.

Woad and other dye plants are also valuable, but require so much accommodation of buildings and machinery as to be quite inapplicable to the general circumstances of an intake. Chicory might do on deep sands when quite freshened.

The benefits of irrigation have been much reckoned on with reference to some recent intakes which afford a command of water, and as an ultimate means something of this kind might be applicable to the higher portions of a level. When, however, it is duly considered that irrigation is only applicable to cases admitting of complete and quick drainage, and that the greatest difficulty in almost all intakes is timely to get rid of superfluous water, it will appear that this mode of augmenting value can but seldom be relied on to any great extent; nor does the farming system of marshes, whether in tillage or grazing, at all assimilate to that in which water meadows are valuable auxiliaries.

To sum up this head of our discourse; the great and leading points for the guidance of the adventurer, in reclaiming his intake, are the following:

1. To freshen gradually;

2. To drain effectually;
3. To cultivate perfectly;
4. To crop moderately;
5. To look to grazing ultimately;
6. To lay down to grass carefully;

and in proportion to the perfect accomplishment of these points, will be the value of his land; *i.e.* it will, in the case of neglect or imperfect execution of them, become only coarse pasturage for young stock, worth from 15*s.* to 20*s.* per acre rent; or in the case of their perfect accomplishment, the lands will come, as near as their soil will admit, to those grazing lands of intakes in Sussex, which carry a fatting ox of 130 stone (8 ℔s.) per acre, and were recently worth £3 to £4 rent; or to those of Kent, which carry six or eight large sheep per acre; or even to some more favoured spots in Lincolnshire, which used to fat *ten sheep per acre to* 40 ℔s. *per quarter, clipping* 14 ℔s. *of wool each;* or others in that county, which carry a large ox per acre and several sheep besides;—all of these instances of vast fertility having formerly been covered by the tide, and rescued therefrom by enterprise and industry.

Reverting however to the probability of such extensive embankments as we are contemplating being undertaken by public companies, the process of culture could not be worth *their* attention. If therefore it should be thought advisable to put the embanked lands under a course of tillage, before laying down to

permanent grass, it might be done by letting in lots to upland farmers who have adequate buildings, of course with proper stipulations as to preservation of condition, &c.; and thus a realization of profit might be made at an early period after embanking, draining, &c., the latter of which should by all means be effectuated by the proprietors themselves, although the culture and ultimate laying down to pasture might be done by their tenants during the period of effecting sales of the embanked lands.

V. THE EXPENSES ATTENDING AN EMBANKMENT.

The probable expense of these works naturally follows a description of them, and although we have already announced that this part of the subject is beset with difficulties, yet we hope to throw such light on it as may enable any embanker to see his way with tolerable clearness.

1st, The expense of collecting the materials for an embankment against the sea may be divided into several classes of cases, thus:

(*a.*) Those of strong, clayey, tenacious soils, such as have been already noticed as occurring on the Essex coast, are performed by the floor of 20 feet square and 1 foot deep, or 400 cubic feet; but in particular localities the floor is 18 feet square, or 324 (or by custom 320) square feet, and 1 foot deep.

Generally, in forming or repairing banks with this kind of earth, a floor of 400 feet cubic, equal to 15 cubic yards, can be barrowed at 100 yards distance,

and packed upon a bank of about 10 feet in height, for about 7*s*. 6*d*. per floor, planks and barrows included, and this is about sixpence per cubic yard. But when the distance exceeds that mentioned, and the height increases, a considerable increase of price is incurred, and this may be calculated after the rate of threepence per floor for every 10 yards in distance above 100 yards, and another threepence for every foot in height above 10 feet; so that a bank 20 feet in height, and the material averaging a distance of 150 yards, would require to be reckoned on as costing about 7*s*. 6*d*. per floor for the first 10 feet in height, and about 10*s*. for the next 10 feet in height; or perhaps sixpence and ninepence per cubic yard, respectively.

At these prices, the men will be able to earn from 2*s*. to 2*s*. 6*d*. and up to 3*s*. per day, according to length of days, weather, time of tides, and their own strength and industry.

When there are rills or channels to cross, the work must be reckoned at full 1*s*. per cubic yard, to allow for loss of soil, and accidents retarding the work.

In practice, a bank 6 feet high and 26 feet seat, containing 60 cubic yards per lineal marsh rod of 18 feet, cost 25*s*. per rod forward to build, which was 5*d*. per cubic yard, the soil being heavy stiff clay.

Marsh ditches or dykes cut in heavy clay soil,

10 feet wide at top, 4 feet at bottom, and 5 feet deep, are usually done at 5*s.* per marsh rod of 18 feet forward, (this being only throwing out, not running or packing,) after the rate of about 2*d.* per cubic yard.

(*b.*) Sandy and gravelly materials on the spot whereon the bank is to be built, may, perhaps, be reckoned to cost quite as much to collect into a bank, as clayey material; for although sand and gravel are more manageable soils, and may be collected with carts and horses, and require less care in packing than clay, yet a greater loss of such loose material will take place by washing away, and even by the action of the wind upon sandy particles. So that these different soils may be taken as on a par with each other, as to the labour requisite in collecting them into a bank upon the spot; all other circumstances corresponding.

(*c.*) The next class of earth-work constituting the cost of embankments, is where the soil of the seat or base of the bank is not deemed safe for the purpose of forming the bank, either by reason of its want of cohesiveness, or from the nature of the ground being such as to render its disturbance dangerous and imprudent.

In this case, the expenses of the work will of course be greatly enhanced, not only by reason of the transport of earthy matter from a distance, but

also by reason of having to purchase the material, as well as to transport it, and form the bank. There are, however, some advantages as a set-off against the expense in this alternative, such as the avoidance of the loss of any part of the valuable ground to be embanked: and what is of still more importance, the avoidance of cutting away the fore shore or foreland lying outside the bank, and so deepening the water immediately outside the bank, and consequently increasing the power of the sea upon it. Still the additional cost will seem at first terrific, and perhaps more so than it really is, when all the advantages are considered; for besides those just mentioned, there is the advantage of not losing material thus collected, in anything like the ratio which is inevitable where that on the spot is used,—and the further advantage in all cases, over sandy material on the spot, of having ultimately a much more safe and substantial bank than any such sandy material would furnish, and probably a consequent saving of bulk or stone-work, equal to the additional expense of a better, though a more distant material; besides which, something may be reckoned for the advantage of earth capable of immediately bearing fresh-water plants, instead of waiting many months before that kind of security can be obtained.

This matter of expense of earth-work is so important in this case, that we have extracted from

Brees' 'Railway Practice,' (1838,) the pith of evidence thereon, given by the most eminent Engineers of the day, in Committees of Parliament.

It will appear from these extracts that the cost of earth-work depends on the nature of the soil, and the distance it has to be conveyed, which is called "*the lead.*" In almost all the instances about to be adduced, the earth was moved by means of waggons on tram-roads with horses, and the contractors had to strip the sod and vegetable mould, slope and dress the banks, and resoil and resod, besides keeping up the work for two years.

1. Evidence of I. K. Brunel, Esq., C.E. (p. 84.)

On the Great Western Railway one item of the original estimate was "Excavations and Embankments, 9,750,000 yards at 1*s.* per cubic yard, £487,500."

"To excavate gravel, which is a tolerable easy soil, and carry it a distance of 3 miles, would be very cheap at 1*s.* per cubic yard, which is the price paid on the London and Birmingham."

2. J. Locke, Esq., C.E. (p. 85.)

"The under-contractors *merely excavate* for 4½*d.* or 5*d.* per yard."

"We have let, on the Grand Junction, about 4,400,000 yards of cutting for about £160,000, or

about 9*d.* per yard,—the average *lead* is under a mile; the longest, 1¾ mile, which is nearly 11*d.* per yard. The extent of the lead, and inclinations of the road, regulate the price." Thirteen pence per yard would be a fair price for 3 miles.

3. Geo. Stephenson, Esq., C.E. (p. 95.)

"The price depended on the material we have had to cut, and varied from 5*d.* to 9*d.*, except at Chatmoss, where it is soft. The Company found planks, tools, and rails."

Upon the Newcastle and Carlisle Railway, Grahamsley and Tredgold contracted for the cutting of Cowran Hill at 5*d.* per yard. They let plenty of it to the workmen at 2*d.* or 3*d.* per cubic yard, but a portion was teamed 1½ mile, which cost 9*d.*, viz. 3*d.* per mile leading and teaming, and 3*d.* for filling.

4. H. R. Palmer, Esq., C.E. (p. 100.)

On the Great Western, found the actual labour was performed (in the plastic clay and sand) at 11½*d.* per yard, with a lead of ·74 of a mile; the men earning 16*s.* per week.

5. G. W. Buck, Esq., C.E.

Measures up and settles for the work. The Watford cutting (in gravel and chalk) cost the con-

tractors 6¾*d.* per yard in labour, the lead being 30 chains;—divided thus,

Cutting and filling	5*d.*	per yard.
Teaming ⅜ths of a mile . . .	0¾	,,
Repairing roads	0¼	,,
Stripping sod and dressing slopes .	0¼	,,
"The lead"	0¼	,,
Oiling the waggons . . .	0¼	,,
	6¾	
Add for waggons, barrows, planks, rails, chains, sleepers, and the like	2	
Making . . .	8¾	per yard.

But some extras bring it to 9*d.* per yard, and "an embankment with a 3 miles' lead in gravel or sand cannot be executed for much less than 1*s.* per cubic yard;" if in clay, more.

The whole of the Watford contract was at 1*s.* 2*d.* per yard; contractor finding everything,—dressing, stripping, earthing, and re-sodding, and keeping in repair for one year.

6. Mr. J. Copeland, Contractor. (p. 105.)

His price for cutting and embanking on the Leicester and Swannington Railway was 1*s.* 2*d.* per yard; the average lead about a mile.

Lets the earth-work in small contracts at about 8½*d.* per cubic yard through gravel, chalk, and sand,

with a lead of rather better than a mile. Waggons, barrows, planks, sleepers, chains, keys, and pins, amount to above 2*d.* per yard more,—making 10½*d.*, besides wear and tear of machinery, at least 1½*d.* more.

7. H. H. Price, Esq., C.E. (p. 108.)

Found contracts come under 1*s.* per yard, *the lead* being under 2 miles.

8. Robert Stephenson, Esq., C. E. (p. 117.)

"The highest price paid on our line (London and Birmingham) for excavation is 1*s.* 2*d.*, which is clay, sand, and marl, with a lead of 1½ mile only. If the lead was 3 miles, should make it 1*s.* 5*d.*"

Mr. Stephenson estimates that when the actual labour is done at 9*d.*, the *current expenses* bring it up to full 14*d.* per cubic yard, those expenses being incurred for contractor's plant, as waggons, rails, sleepers, &c., and for repairing them and the roads, compensation for materials, and roads to convey the same, timber, sleepers, iron, &c., carriage, wharfage, &c., together with interest of money expended during the progress of work; and this he states to be exclusive of contingencies, such as slips, &c., and of re-sodding the surface.

"Would add 2*d.* per mile more if the lead should increase. The soil is bad, being the upper part of

the London clay mixed with alluvia." He calculates that St. George's Hill, if in clay and sand, would cost 12½*d.* per cubic yard; if clay prevails, more; the lead 3 miles. Locomotives would perform the lead at 1½*d.* or 2*d.* per mile; carts and horses, 2*d.* Estimated 111 miles at 12½ millions of cubic yards, on London and Birmingham line at 14*d.* per cubic yard. Cowran Hill, on the Newcastle and Carlisle Railway, he put at 10*d.*

9. C. Vignolles, Esq., C. E. (p. 136.)

Estimated on Brighton line 11,134,042 cubic yards of earth-work at 9*d.* per yard, one-third to spoil bank (or waste); average lead, one mile.

On the North Union Railway, one of the contracts was for "running into temporary spoil and afterwards carrying into ballast," 4*d.* per yard; for waggoning 220 yards, 6½*d.* per yard; for 900 yards, 8½*d.* per yard; for 1¼ mile, 11*d.* per yard. The average price of all the excavations, with the slopes and cuttings trimmed, but exclusive of soiling, 10½*d.*; for soiling and re-soiling, 1*d.* super. The work is in clay, and the lead from 1 to 1½ mile. In one of the contracts, where the lead does not exceed half a mile, the price is 8*d.* per cubic yard; the contractor gets it done for 7½*d.*, but he finds waggons, rails, and sleepers. In general the value is 9*d.* in clay, 8½*d.* in sand, for the first mile or under; 3*d.* more the second

mile, 2*d.* for the third mile; but the general rule is, to add 3*d.* per yard per mile, after filling the waggons.

10. Colonel George Henderson, Royal Engineers. (p. 181.)

Observed the operations about Shapley Heath, (Southampton Railway,) for two days; took account of men and horses employed, and found the excavation cost less than 3¾*d.* per cubic yard; the men earning 2*s.* 10*d.* per day for filling at 1¾*d.* per cubic yard: horses, 4*s.* 10*d.*; teamers, 2*s.* 6¼*d.* per day, at ½*d.* per yard. Some of the cutting was let at 5*d.* per yard. Mr. Pease gave evidence in the House of Lords last year of earth-work done at 4*d.* and 5*d.* per yard; has no doubt it was correct.

11. J. W. Rastrick, Esq., C. E. (p. 197.)

Estimates earth-work as under:

	Getting.	Filling.	Spreading.	Total.
Clay	1½*d.*	2*d.*	1*d.*	4½*d.*
Chalk . . .	0½	2½	1	4
Sand	0½	2	1	3½
Stone or Marl .	2	2	1	5
Red Sandstone	6	2½	1½	10

Besides 3*d.* per yard teaming first half-mile, and 3*d.* per yard every other mile.

12. Francis Giles, Esq., C. E.

On the Southampton line.

Let 5,000,000 yards at 6*d.* per cubic yard: says, "I shall carry the work through at a fraction above 6*d.* at the London end, and less than that price at the other end, making about 6*d.* per yard from end to end. I am not paying above 5*d.* for excavating, except in one case, which is at Kingston, where I pay 5½*d*,, the upper part of this hill being stiff clay, but the lower part is milder." The Company find waggons, tools, horses, and all other materials, and stop 1*d.* per yard till they are redeemed at prime cost; they then belong to the contractor. Considers Colonel Henderson's calculation very nearly correct, or say 4*d.* per yard. Allows the contractor 5*d.* per yard.

Estimates all expenses of earth-work at 5½*d.*, clay and gravel, and 4½*d.* sand, for 1½ mile lead; half the quantity used, the other half moved to spoil banks. "I have let the (River) Mole embankment with an average lead of 3½ miles for 6*d.*" Averaged earth-work on Great Western 7½*d.*, and Carlisle at 7*d.* One contractor failed at 6*d.*, but his assignees carried it on and paid his debts out of the profits.

He estimates the cost of earth-work per cubic yard, as under, for 1½ mile lead:

	For clay and gravel.	Sand.
Waggons	$0\frac{1}{2}$	$0\frac{1}{2}$
Horse-draft and boy . . .	$0\frac{3}{4}$	$0\frac{3}{4}$
Men, horses, &c. getting in and out of work	$0\frac{1}{4}$	$0\frac{1}{4}$
Getting and filling . . .	$2\frac{1}{2}$	$1\frac{1}{2}$
Teaming	$0\frac{1}{2}$	$0\frac{1}{2}$
Trimming banks	$0\frac{1}{2}$	$0\frac{1}{2}$
Laying and keeping up roads, oil, boy, and drains, on a large scale of work	$0\frac{1}{2}$	$0\frac{1}{2}$
	$5\frac{1}{2}$	$4\frac{1}{2}$

Clay and gravel half moved, $1\frac{1}{2}$ mile,	$6\frac{1}{2}d.$
Sand the other half to be used .	$4\frac{1}{2}$
Making . .	11
Mean . .	$5\frac{1}{2}$

Locomotive 2*d.* per cubic yard.

13. W. C. Mylne, Esq., C. E., &c. (p. 227.)

Approves Mr. Giles's prices. Earth-work contract at Shapley Hill was at 6*d.*, but found the work doing at $3\frac{3}{4}d.$; fillers earning 3*s.* and teamers 2*s.* 6*d.* per day; the lead 830 yards. "*Four men can fill and wheel* 60 *cubic yards of clay a distance of* 20 *yards per day for* 14*s.*, *which allows each* 3*s.* 6*d. per day, and averages* $2\frac{3}{8}d.$, *say* 3*d. per yard, and allow* 1*d. more for each additional* 30 *yards.*" A contractor had 10*d.* for deep-

ening the Cam, and stopped; another did it for 6*d*., and paid the debts with the 4*d*. profit. *Sandys Cut*, near Littleport, cost 2*d*. getting, filling, and wheeling peat,—3*d*. for heavy silt; the men earned 3*s*. 6*d*. per day.

These, however, are the prices for soft-digging earth, since stone, even when not under the conditions of hard rock, will cost 2*s*. 3*d*. to 3*s*. per cubic yard, to get and convey the same distance.

Upon a very careful analysis of these estimates of earth-work, we find the first nine to take a higher ground of calculation than the other four, the latter being somewhat in opposition to the former. The whole give the following results; viz., of the first nine evidences, there are

10 estimates including implements, that is, waggons, rails, &c., &c.; average lead 2¾ miles at 14*d*. per cubic yard, and

14 estimates are, without implements, at 10*d*. per cubic yard for a lead of 1½ mile: adding the additional mile lead and the implements would bring these to about the same,—14*d*. per cubic yard.

The other four estimates authorize a statement of 13 instances giving an average lead of 2 miles, and a price of only 7¼*d*. per cubic yard. The average of the two sets of evidence would be about 11*d*. per cubic yard for 2½ miles lead. Several of the engineers also

agree that 3*d.* the first mile (some say, half-mile), and 3*d.* per mile afterwards, is the fair calculation, and this would bring it to 9*d.* per yard for 2½ miles, which is about the distance the materials will have to be carried for an intake of 1000 acres,—namely, nearly a mile from the shore on each side, and about the same to the gap left for shutting up. This, however, is the full, not the average distance, and as this lower scale of prices above-mentioned is the result of practice, we should be justified in taking 9*d.* per cubic yard in satisfaction of all these considerations; but we may, however, under all the circumstances, and considering that some allowance is to be made for tide-work and night-work, for bad weather on the coast, loss of materials, and for a much smaller scale of work than railways, feel quite on the safe side in charging the sea-bank with 1*s.* per cubic yard for all the materials brought from a distance.

Taking the foregoing particulars as data for the earth-work of the bank proposed in the diagram A, and taking that bank to have a sectional area of 60 cubic yards per yard linear of the bank, and supposing that a portion of this bank, say one-third, is raised upon the spot at 6*d.* per cubic yard, and the rest has to be brought from a distance at 1*s.*, an average of 10*d.* is given; but still for safety adhering to 1*s.* for the whole, we have a sum of £5280 per mile, viz. £1 per foot linear.

But the bank of the diagram A is one of the very largest dimensions which is likely to occur, not only throughout the whole line of an intake, but to occur at all, since it pre-supposes the tide to rise to the height of 14 feet at ordinary springs, viz., 4 feet *up to* and 10 feet *on* the bank, and occasionally to 19 feet, exclusive of the swash.

A more probable height of extreme tide in most cases would be 16 feet; and then the main bank would be 8 feet high, and the outburst bank 4 feet more, with a swash bank of 2 feet more. Such a bank would contain about 40 cubic yards per yard lineal, and the cost per mile would be about £3520.

But upon a considerable portion of every intake, and probably on the greater number of intakes, generally the tide will not flow more than 10 feet at ordinary springs, in which case the main bank will not be more than 6 feet in height, and the outburst and swash banks 4 feet more. In such cases the bank will contain but about 20 cubic yards of material to every yard lineal, and will cost only about £1760 per mile, or even less, since the distance and height being diminished, the cost of collecting the material is lessened.

In like manner, as the ground rises, or the bank joins the uplands, its dimensions will decrease, and its cost come down to, say, £1000 per mile.

Every line of embankment may fairly be supposed

to contain a certain proportion of each of these heights of bank; thus, in crossing channels, the largest bank may be required to a certain extent, say, one-eighth of the whole distance. The second class of bank may prevail over the general level of the line, but ridges and banks will probably occupy some portion of it, and these may respectively be taken at one-half and one-quarter of the distance, whilst the approaches to the shore, being over the high skirts and fringes, can hardly occupy less than one-eighth of the line. We shall take their proportions as below, namely;

$\frac{1}{8}$ bank, being $17\frac{1}{2}$ feet high, at	£5280	per mile.
$\frac{1}{2}$ bank, being 14 feet high, at .	3520	,,
$\frac{1}{4}$ bank, being 10 feet high, at .	1760	,,
$\frac{1}{8}$ height of bank, being much less, at	1000	,,

We may thus take the average cost per mile, for the sake of even numbers, at about £3000 for the earthwork only, or bulk of the bank, including also the gravel at sea foot.

2nd. The expense of the *facing* of the bank comes next under consideration, and this must depend upon the distance which the stone for that purpose has to be brought, and the price at which it has to be bought.

In cases where pitching has been thought neces-

sary, and *that* 18 inches deep, the cost of it has been valued by eminent persons at 2*s.* per square yard, the stone having to be brought some miles: this was mica slate, and being set edgeways, had disintegrated and become firm by the interstices filling up. And on most occasions two shillings per square yard is more than abundant for the cost of stone-facing a sea-bank. In cases where the stone is within reach of the tram-roads, the rationale will be thus:

A cubic yard of stone may generally be won, and trammed between 1 and 2 miles, for 1*s.* 6*d.* to 2*s.* per cubic yard. Two men will place about 6 square yards of this material, from 15 to 18 inches deep, in a day, and their wages will be, say 4*s.* The account therefore will stand thus:

	s.	*d.*
Stone, laid 15 to 18 inches deep, say 3 cubic yards, at 1*s.* 9*d.* per yard .	5	3
Labour to 6 square yards . . .	4	0
	9	3
per square yard . .	1	6½

but as the full 18 inches in depth will not be required, and in many instances stone will be got near to the bank at a lower rate per cubic yard, we may safely take it at 2*s.* per square yard; so that taking the quantity shown in the diagram at 7 yards

superficial, for every yard linear, the cost will be at 2*s*. per yard £1232 per mile, or less, for the first class of bank. If therefore we say £1250, £1000, and £750 for these classes, or £1000 per mile on the average of cases and the medium class of bank, we shall be far within the safe side of expense, which in all these cases is desirable.

These are the chief features of cost in the construction of sea-banks, and although there are other incidental costs which will inevitably swell the total amount, yet having already accounted strictly for the cost of these two principal features, the work may, on the large scale, usually be done so much beneath these estimates as to cover all the incidental expenses attending it. Still there will be but a proper degree of prudence in allowing a per-centage on the whole for unforeseen contingent expenses; and in such a case as sea-banking, 10 per cent. will amply cover every expense not already mentioned, for putting it into a condition to sustain itself against the fiercest attacks of the ocean.

It must however be remarked that this estimate contemplates embanking on a large scale and in exposed situations, whilst there are other cases where embanking may be highly desirable, although the ground to be gained may be of more limited breadth and extent. In all such cases, as well as those of a larger extent, the quantity of materials and labour,

and consequently the amount of expense, will be in proportion to the depth of water and the degree of exposure, together with the eligibility of the materials on the spot. It is, however, highly probable that in proportion to the near approach of any embankment to the land, or, what is often the same thing, its absence from great exposure, so will the cost of embankment be diminished as its bulk and expense of stone facing diminishes, as well as the contingent expenses thereof. In which case it is probable that the aereable expense of the embankment may remain the same as when on a larger scale: and in most of such minor cases of those fringes being embanked, there is a vicinity of materials and other local advantages, which would render one shilling per cubic yard a safe estimate of the probable expense of any such bank, including its stone facing.

3rd. The cost of *drainage* will vary much according to the peculiar circumstances of the case; but the process of making catchwater drains to intercept the high-land waters,—of forming the circular drain or delph leading to the sluices,—of laying down the sluices themselves,—and of cutting the necessary circular or exterior main drains to convey the waters from the surface, cannot be estimated in favourable cases at less than the following detail, as applied to an intake of 1000 acres, viz.

4 sluices, of 3 feet run each, £150 each, say	£ 600
Steam-power, say	500
600 rods of catchwater drains, at 5*s*. . .	150
3½ miles of circular drain and fence, at 4*s*. per rod	250
Gripping at 1½*d*. or 2*d*. per rod, say . .	500
Total on 1000 acres . .	£ 2000

4th. Thus making the whole cost of recovering the lands from the sea as under, viz.

Cost of 3½ miles of bank	£ 15,750
Cost of drainage	2,000
Add contingencies, cost of management, &c., say	2,250
Making .	£ 20,000

as the price of 1000 acres ready for culture.

VI. THE BENEFITS LIKELY TO RESULT FROM EMBANKING LANDS.

The benefits and advantages which may reasonably be expected from the embankment of lands against the sea, will evidently appear, from the foregoing observations, to be dependent on many circumstances; the chief of which will be the acreable expense of the embankment, and of the subsequent drainage of the land, combined with the natural fertility of the soil itself.

In our inquiries into such returns, the first question is, what would be the probable value of the land embanked, if drained in the manner already stated? To which it may be replied, that the soil of an intake is usually of so fertile a nature, so fresh, and so capable of bearing valuable crops of corn and grass without manure, that in any kind of convenient locality, there has never been any difficulty in realizing from £30 to £50 per acre, at the moment of the embankment and general drainage being completed; and we shall quote hereafter, amongst examples of embankments, an instance of part of an intake readily fetching £40 per acre at

the moment of the sea being shut out, viz. No. 1 of the examples quoted in section IX.

The full *difference* of this cost and this value will be enjoyed in cases where the embankment is made by the parties whose lands adjoin the shores, and in whom is vested the adjoining frontage to seaward. When any one such frontager has the opportunity to make an embankment, or when an intake can be made by the joint efforts and co-operation of two or more such parties, the advantages to them are considerably greater than to any stranger, inasmuch as such lands, when well reclaimed subsequently to embankment, become very useful auxiliaries to the uplands of the same estates, by often enabling a farmer to put his stock into the best condition for market, instead of being under the necessity of selling them to a great disadvantage, from being unable to forward them to the profitable point whether of fatness or of age and growth. This is a matter of so much importance to a farmer, that in the Wealden, marshes are hired by them for this purpose, at 20 to 30 miles distance, *i. e.* in either Romney or Pevensey Levels. When therefore such marshes can be supplied in the same parish, or perhaps adjoining the same farm, the convenience is such as to add to the value of the whole estate, over and above the intrinsic value of the marshes themselves, which are gained from the sea. Hence, an adjoining proprietor can afford to gain these marshes at a greater expense per acre than the specu-

lation of a stranger would render prudent, and the more especially as he escapes all those parliamentary expenses, head rents, and other drawbacks to which the stranger is subject. It may, therefore, be extremely well worth while for an adjoining proprietor to make an intake of his sea frontage, under circumstances of a much less favourable nature than a mere speculator; thus he could prudently embank a lesser breadth of shore than the speculator would find worth his attention, and he could afford to incur a greater expense per acre than the speculator could prudently venture. In general, however, it is only the frontage pasturable verges that have been thus embanked by proprietors, and it is to be lamented that in many, if not most cases, it has been deemed a sufficient exertion of enterprise to shut out the sea, whilst the subsequent reclamation has been either entirely neglected, or performed in so slovenly a manner, that the marshes thus gained still present a rough uneven surface, a large portion of which is occupied with those "lows," "pans," or "hollows," which bear but a scanty herbage of the coarse aquatic grasses, of so little value, that 15*s*. to 20*s*. per acre, tithe-free, has been the rental even when the soil and other circumstances might have commanded double that amount, with greater advantages to the occupier, if those foregoing detailed processes of reclamation had been duly attended to. In the latter case, marshes in Lincolnshire are recorded by Arthur Young

as carrying a large ox and several sheep per acre. Around Wisbeach 18 acres of grass marsh for many years fatted off 200 of the old large Lincoln sheep to 40 ℔s. a quarter, each clipping 14 ℔s. of long wool. In Pevensey Level, in Sussex, an acre commonly fats off an ox of 120 to 130 stone (8 ℔s.), and carries several store sheep besides; and in Romney Marsh, six to eight large sheep per acre are a common stock.

The processes of reclaiming which more immediately appertain to the proprietor, as distinct from farming operations, are, 1. cutting the interior marsh dykes to divide the intake into convenient marshes; 2. placing gates and side-rails to those marshes; and 3. making the requisite occupation roads,—and these he can probably agree with a tenant to get done under a system of reasonable allowances.

These results are, however, subject to all those drawbacks to which speculators must be liable, in order to gain a footing on any shore, viz. the expense of Acts of Parliament—the shares of proprietors of adjoining lands—and the rents reserved upon the lands embanked. These will lead, under another head of this discourse, to the consideration of those expenses, impediments, "lets and hindrances," which do or may occur to speculators upon an intake, with the fair means of meeting them.

VII. THE OBSTACLES TO EMBANKING LANDS FROM THE SEA.

Those preliminary costs and impediments which adventurers in the embankment of lands from the sea have most usually to encounter, previously to their being enabled to commence their operations, or to reap the fruits of them, have in their general nature and amount been already touched upon, and may now be mentioned somewhat more in detail, under the following heads; viz.

(*a.*) *Parliamentary expenses.*—In almost all cases where the embankment of a large space or extent of sea frontage is contemplated, several frontagers, or adjoining proprietors, will have to concur in the measure. The endeavour to bring about the unanimous concurrence of many persons to any one common measure is so seldom attended with success, as to be almost hopeless,—and its success, if ever happening, may be considered rather a piece of good luck, than the result of management, the reward of address, or even the natural effects of a fair view of his own interests, taken by each individual concerned. Besides, it rarely happens

that all the parties whose concurrence is requisite are in a position to give such consents as may be legally binding on their successors, so that it becomes, in so many cases, absolutely necessary to resort to legislative sanction, that prudent persons will lose no time in applying to Parliament, as soon as they have obtained sufficient consents, in number, of the parties concerned, and a sufficient proportion in value, to enable a Parliamentary Committee to entertain the Bill; and a Committee of the House of Commons is *now* so well constituted as to afford one of the most patient and impartial tribunals that can be desired, for the purpose of deciding between projectors on the one hand, and objectors on the other. We have witnessed this fact on several late occasions, including one, on which fifteen gentlemen gave, for thirty-three days, the most unremitting attention to a project for the better drainage of about 140,000 acres of lowlands, which project was promoted on one side by a host of engineers and other witnesses, and opposed on the other side by an equal host of engineers and other witnesses. And this is mentioned, though somewhat irrelevant to the case before us, in order to reconcile every party to a tribunal which, *in such cases*, appears to be almost as good as human institutions admit. Such a Committee may be taken, as in general, favourably biassed towards the party who proposes to employ capital in any great and important improvement on the face of the country,

whilst they hear and weigh every objection that can be made to the proposed measures, and are careful to secure the ways and means of carrying those measures into effect, and also to impose upon the adventurers all reasonable conditions for satisfying the interest of other parties, who may be affected by those measures. This being the case, the general regulations which are to bind all parties concerned in a legal point of view, cannot be better arranged than by an Act of Parliament, which is generally first drawn and concocted by acute and right-minded men acquainted with legislative language, forms, and usages, and subsequently deliberated upon, clause by clause, as soon as the Committees of both Houses are satisfied that the allegations of necessity or benefit to the promoters are proved to their satisfaction, under the name of *the Preamble* to the Bill.

The provisions of such a Bill will have for their object, on the one hand, to secure the public, the frontagers, and all other parties, in a continuance of enjoyment of all their property rights, privileges, and conveniences, *or* a compensation for the loss of them. And, on the other hand, to secure to the undertakers the fullest means of carrying their project into effect, and the fullest enjoyment of it when effected.

But all these advantages cannot be obtained without a considerable expense, which will fall upon the adven-

turers,—and this will be greater or less, in proportion to the degree of opposition that is made to the measure in its progress through Parliament. It behoves, therefore, the promoters of such a Bill to disarm opposition, as much as possible, before the Bill comes into Parliament, by every fair and reasonable concession to, and compliance with, the wishes of interested parties; and this is good policy on another ground, viz. that of lessening the chance of defeat, by predisposing the Parliamentary Committee in their favour. But even at the best a contested Bill must be a matter of some cost, which might be avoided or lessened by previous consents.

(*b.*) *One-tenth of the land embanked* has been mentioned as the probable expectation of the frontager, in consequence of that proportion having been given in some considerable cases of this kind, and this over and above such pasturable verges or grassy fringes as have already been subject to acts of ownership and occupation on the part of the frontager; and these reservations sometimes form so great a drawback upon the probable profits and advantages of the speculation, as to deter from the attempt all except such enthusiastic persons as view the prospect of advantages through so magnifying a medium, as to exhibit prospects of a golden harvest after many and great diminutions.

But one-tenth is, really and truly, a larger deduction than almost any intake will allow, so as to leave

remaining to the adventurers a sufficient chance of adequate remuneration for their enterprise.

Still, the frontager must be compensated, since he loses several conveniences and "easements," as the law has it, of some value; such as the feedage of the pasturable verges or "skirts," which to him are in the nature of a "shift" for his sheep, young cattle, and horses: he loses also something from having the sea further removed from his upland, and if he gets manure from the shore, the embankment will be some hindrance, and he loses the opportunity of making the same speculation as the adventurers. There are some cases analogous to that of these frontagers, viz. that of the Lord of a manor when the waste or common of the manor is about to be enclosed, of which he usually gets from one-twelfth to one-sixteenth, in respect of his manorial rights,—viz. his absolute right to the soil and a portion of the herbage, and his right, by custom, of granting portions of the soil to copyhold tenants, subject to small quit-rents, and a fine on death or alienation, which often goes to the extent of two years' value on death of the copyhold tenant, and a year and a half's value on his alienation.

The Lord has also a right to all the timber growing on the waste, and a legal right to all the timber growing on the copyholders' lands, but this latter is generally commuted by custom to one-third of the timber. This is the position of the Lord of a manor, and in case of

an enclosure, he is in the enjoyment of actual property to a greater amount than any frontager to seaward, where slobs or mud-banks have been covered by every tide. The actual share of waste lands allotted to a Lord in such cases is seldom more than a sixteenth, but is sometimes a twelfth, and in some cases may be only one-twentieth.

Then, again, in the cases of mines or quarries, the royalty, seignorage, or groundage varies according to circumstances, from one-eighth to one-twelfth, one-sixteenth, or one twenty-fourth; and it may indeed be stated generally, that where valuable but dormant property belongs to one party who is either unable or unwilling to encounter the expense and risk of rendering it available, the possessor of that property usually receives, from any other party who is able and willing to work it, a share of the proceeds, of which one-eighth to one-twelfth seems to be the maximum, and one-sixteenth to one twenty-fourth the minimum, fluctuating according to circumstances between those proportions, and affording a fair medium, say *one-fifteenth*, as the fair share of an intake to be rendered to the frontager, in lieu of his present rights in and over such slobs, &c. as have been covered by every tide. And the frontager ought to reflect, that although the embanked marshes may belong to others, their existence in the vicinity of his upland farms will enable his tenants to hire them to the great advantage of his property, as before ex-

plained, with reference to the occupation of marshes attached to uplands, and of marshes hired by upland farmers, though at great distances.

As to the pasturable fringes, it would be very disadvantageous for any adventurer to lose them, since the great disadvantage of the kind of property created by an embankment is the uniformity of its nature and the absence of that change of soil, of aspect, of herbage, of crop, and of all local circumstances, which is found so congenial to all kinds of stock, and so requisite to the successful operations of farming in all its branches. This change is expressed amongst farmers by the word "shift," a term denoting the power of change, which is reckoned important as applied to pasturage,—thus, for instance, cows after feeding all the summer on the higher grounds, called leasows or leazes in the dairy counties, are brought with peculiar advantage in autumn to the rowens or after-grass of the low meadows which have been mown for hay.

Now the only alleviation of this disadvantage of an intake is to be found in the higher levels of land, which constitute these fringes, or pasturable verges along the highland edge, which on the eastern coasts of England are called salts or saltings; but on some portions of this coast, and more generally on others, these verges consist of shingly or sandy dunes, or downs, which are very seldom covered by the tide even at outbursts, and such spots not only afford the only

approximation to what is called *a shift*, but they also afford the only safe and secure, as well as healthy place of habitation, and for the folding of cattle for shelter.

These verges, therefore, ought by all means to form part of the intake, and cannot without great loss to the adventurers be dispensed with. So that the Bill or Act of Drainage and Embankment ought to include the frontager's verges up to the present sea-defences, if he has any, and if not, up to the high-water mark.

It ought, however, to be recollected that the frontager will be relieved from all future expense of sea-defences, and of all the damages which the sea may possibly occasion to his property, and on that consideration he should in fairness class his verdant frontages with the other lands to be embanked.

(*c.*) It may not, however, be so convenient to a frontager to have an allotment of one-fifteenth *of the land* to be embanked from the sea, as to have a money rent reserved on the whole of the land gained in lieu of such allotment, and it then becomes a question what this rent ought to be per acre. Now, assuming one-fifteenth to be the fair proportion of land to be rendered, the value of that land, *when embanked*, and *before* any of the operations of drainage or reclamation have commenced, is the problem to be solved; and taking this on the average at £35 per acre, it gives £2. 6*s*. 6*d*. per

acre as the fifteenth, say 1*s.* 6*d.* per acre per annum, over all the land to be embanked, which really appears to be a fair remuneration of the rights of the frontager, and as high a chief rent as the adventurer can well afford or the frontager ought to expect, seeing that many other advantages will accrue to him from the embankment and drainage about to be accomplished.

(*d.*) The parliamentary costs of such speculations as are under consideration have already been adverted to,—but besides these, the professional and personal expenses attending the various treaties and agreements with individuals and corporate parties interested, —the levels, sections, plans, and reports, that would be requisite from engineers,—the journeys,—the employment of many agents, and all the various contingent expenses that will inevitably occur, must amount in the aggregate to a considerable sum: but as larger quantities would be the most likely to become the subject of Acts of Parliament, this head of expense per acre would be lessened as the quantity increased.

(*e.*) We must next consider the expense of works not exactly appertaining to the embankment, drainage, or reclaiming, and though not entirely without use for those purposes, yet chiefly rendered necessary for the convenience of adjoining proprietors;—viz. *roads* required for the continuance of the communication which they have heretofore enjoyed,—drains required to carry off waters from their uplands,—and the con-

tinuance of those sea-easements, such as the navigation of creeks and rivers, and the like, to which they may have been accustomed, so far as may be compatible with the grand objects of the embankment. Such works as these cannot fail to incur a considerable expense, especially if the intake be on a large scale, and, like the preceding head of cost, these expenses will be more or less per acre, according to the number of acres embanked.

(*f.*) Thus in estimating the probable benefits derivable from an intake on one hand, and "counting its cost" on the other hand, we may probably take the following statement as the result of good management in such cases, attended by such a share of good fortune as might reasonably be expected, viz.

Value of 1000 acres embanked and drained		£40,000
Cost of embanking and draining	£20,000	
—— of 1*s*. 6*d*. per acre for $\frac{1}{18}$th	1,500	
—— of occupation roads, gates, &c. &c.	1,500	
—— of Parliamentary, Professional, &c. . . .	1,000	
—— of extra works, &c. . . .	1,000	
	———	25,000
At £40 per acre, profit . . .		15,000
At £35 per acre, profit . . .		10,000
At £30 per acre, profit . . .		5,000

subject [illegible]

the period [illegible]

But the [illegible]

speculator [illegible]

kind, [illegible]

of a [illegible]

(a. The [illegible]

such a [illegible]

the most [illegible]

fro[illegible] [illegible]

ventures [illegible]

by their [illegible]

share [illegible]

The [illegible]

pared [illegible]

fairly and [illegible]

shall [illegible]

interests [illegible]

speculators [illegible]

considered [illegible]

ager in a [illegible]

to be [illegible]

sidered [illegible]

acceptable [illegible]

them, [illegible]

and that [illegible]

the measure [illegible]

being made whilst the speculation was rife, and the parties inclined to adventure their capital.

(*b.*) Such an offer would best be made through the medium of a draft of the Bill proposed to be brought into Parliament for effectuating the intention of the parties, showing at once in a clear and candid manner the terms proposed, as affecting all the parties interested; and appended to such a draft a lithographed map or plan of the ground proposed to be embanked, —of the line of embankment,—a section of the bank intended, and a plan of all the adjacent rivers and streams and other features of the country,—the roads intended to be carried out, and the drainage to be made or continued, together with an engineer's report, specifying the data on which the proposed works are founded, particularly the rise of the highest tides and of the greatest outbursts. It is indeed matter of regret that engineers of late years have dropped that very satisfactory mode, which was adopted by Smeaton, of giving the chief local data on which their plans are founded.

It is true that many if not most persons would deem it matter of policy to raise high, but vague and indefinite expectations at first, and to clothe the whole matter with a mysterious cloud, under which they might expect to obtain advantageous terms, and to prevent the true interests of other parties

from being clearly seen or insisted on. *Such* policy, however, invariably turns out to be *bad* policy; it induces suspicious notions in the other parties, and causes them to be always on the watch and never thoroughly satisfied; and thus creates expense and delay, and lays the foundation of never-ending litigation. We therefore entirely deprecate such policy, and advocate a candid, open, and fair statement of the project,—of the means by which it is intended to be effected, and the manner in which it is proposed to deal with all the existing interests. Such a statement, together with a draft of the proposed Bill, being sent to every individual whose consent is requisite, inviting his remarks thereon, private conferences would take place, and long before any public meeting, (if such meeting should be at all necessary, and if not, it should be avoided,) or before the Bill was brought into Parliament, the promoters of the measure would be in possession of the sentiments of those concerned, and be enabled to judge as to what amendments were desired, and which of them it would be expedient to adopt, or whether the objections of opposers were so strong as to render it prudent to withdraw the Bill either altogether, or till "a more convenient season;" and, on the other hand, they would be enabled to estimate the nature and degree of opposition they would have to encounter, and the probability of carrying the Bill against that

opposition. Such an open and candid mode of proceeding in the first instance would be most advantageous to the cause of the promoters, and this mode would dispose the frontagers and others to give better terms, to accept lower compensations, and be content with less expensive accommodations, and finally to become well-wishers to, instead of opposers of, the work. This candour would also have a very important effect before a Committee of Parliament, and create a prestige much in favour of the promoters, which they would find to their infinite advantage.

VIII. OF THE PARTIES TO AN EMBANKMENT; THEIR RIGHTS AND DUTIES.

Such a mode of proceeding as we have thus proposed presupposes the existence of very clear and well-defined notions on the part of the promoters of *what are* the actual rights of all the parties concerned, and how they ought to be provided for; a species of knowledge neither very general nor easily acquired amidst the warmth and zeal attending projects, and therefore some investigation of it in this place may be useful.

1st, The rights of the *public* are involved in all such projects by reason of the propriety and necessity of continuing to them the conveniences and accommodations which they have hitherto enjoyed; viz. of roads to the sea-side, navigation of the sea and of the rivers, and that general species of drainage which such rivers, together with the smaller brooks and streams, may have hitherto afforded.

With these views, therefore, all *public roads* should be continued across the embanked lands to the sea;—and this according to certain dimensions and certain rules as to quantity and disposition of materials, and under certain arrangements for drainage and for future

maintenance,—all of which should be clearly expressed in specifications, either referred to by the Act or annexed by way of Schedule thereto; and the lines of such roads should be laid down on the parliamentary plans, the detail of execution being left to be determined by Commissioners named in the Act, after the manner of Inclosure Acts, or by some public officer to be named in the Act.

As to *rivers* also, the avoidance of any obstructions to their discharge into the sea should be secured by their embankment on each side across the slobs or shores to be gained, and the lines of these banks should be laid down on the parliamentary plan with an ample degree of divergence, so that the river waters may have a due space for their outfall and escape to seaward. The height and dimensions of these banks should also be specified and fixed by the Act, so as to secure their being made of such elevation and strength, that neither the tide itself, nor tide and floods together, may be able to overtop or break them; and yet that the land-flood waters may not be impeded so as to drown the lands situated above the intake. These points as to rivers ought not to be left to the projectors, who might not be aware of the quantity or force of waters coming down a river, or of the liability of that river to flood the grounds near its mouth, or of the lowness of such grounds upon some part of the course of such river. It would therefore be very expedient

that some engineer should certify on the part of the public, as well as on the part of the proprietors of lands adjoining such river, that the proposed river-banks will be good and sufficient for all these purposes; and hence, amongst other reasons, the necessity of the engineer's original report specifying the height of tides, and other particulars or data, as mentioned in a preceding page.

And these points being secured as to rivers, that of the navigation of those rivers should also be protected. It is sometimes of great consequence to a tract of country that either the actual power of navigating to a certain point up the river, or at least the capability of rendering the river navigable to such point, should be preserved; but this is in great danger of injury or annihilation when embanked, by reason of the accumulation of detritus brought by the stream down from the upper country. Any alteration of the stream, therefore, becomes of great importance in a river where such detritus is abundant; and the width at which the banks should be set, their direction, and the degree of their divergence, are matters of equal importance; since the natural bias of the projectors will be to place the river-banks as close as possible, in order to avoid diminishing the area of the intake, whilst the danger of their being too close is, not only want of sufficient *space* for tide and flood, but such an accumulation of detritus as to have an insufficient *depth* for tide and flood,

and totally to destroy navigation. To obviate these difficulties it may be requisite to deal with these rivers far above the bounds of the intake, and to deepen, widen, and embank them, so as to secure them against every mischief to which they may be liable, in consequence of the works of the intake;—but this ought certainly to be done by, or at the expense of, the projectors or promoters of the scheme, therefore it might best suit all parties, if such matters as these were left to be finally determined in detail by Commissioners named in the Act, although some general outlines ought to be laid down by the Act itself, founded on a previous examination of the case in respect of all the rivers interfered with; and should any works done by the projectors, extra those necessary for the embankment, be greatly beneficial to the public and place them in a better position than before, the district improved by such advantages of roads, navigation, drainage, &c. should by assessment pay the value of such improvements,—the assessment to be imposed by some competent persons in manner to be described in the Act.

In matters of *drainage* also, the public may be much injured by the projected embankment; care therefore ought to be taken to secure the complete drainage of the lands embanked, so as to prevent malaria, or any unhealthful effects of stagnant waters, as well as to prevent any stoppage of such drains as have hitherto

carried the upland waters to sea; as, without such precautions, public roads may be inundated, and public bridges may be injured; but, on the other hand, waters may be lowered, roads improved, and bridges rendered unnecessary, in which case the county or district publicly benefited should render some adequate and equitable compensation in manner before mentioned.

In the case also of navigation seaward, the public will necessarily be driven to a greater distance from the usual landing-place on the shore, and this disadvantage should be compensated by commodious landing-places being provided, conveniently situated with respect to the roads that are to cross the intake,—and in case of quays or wharfs built by the projectors, they should be allowed to charge tonnage or other dues limited by the Act.

The public also ought to have reserved to them the customary power of collecting such substances as the sea affords on many parts of the coast, such as shingle, sand, boulders, sea-weed, shells for manure, sea-mud, &c., &c.: as the unlimited exercise of those powers as hitherto enjoyed might be injurious to the embankment, it ought to be limited within a certain distance of the foot of the bank; but as the public will still be sufferers from the greater distance which these substances will be removed from the land, they ought to be compensated by some common, public, free landing-place for such substances being provided on some of the

navigable rivers, at some place at least as convenient with respect to distance from the sea as the former shore; and in consideration of the probability of the quantity of several of these substances being decreased by such embankment, these landing-places ought to be situated as high up the country as the river can be easily made navigable for the craft usually employed.

But a question naturally arises out of these observations, as to the means by which, and the parties by whom, these public concerns are to be secured; since it is vain to expect much anxiety with respect to these points to be evinced by either of the other parties concerned, viz. the proprietors or the promoters,—the first being only intent on the best terms they can obtain, and the other on the hazard and profit of their enterprise. It is therefore only in the Committees of the two Houses of Parliament, that any security can be looked for to the public interests in these cases, and if such adventures should become as frequent as the redundancy of capital and the enterprising spirit of the age render probable, there will most likely be a general preliminary Act brought in, regulating such matters on the part of the public, and at the same time facilitating their operation on the part of the adventurers in a manner similar to the Act called "The Duke of Bedford's Act" regulating the forms, &c. of Inclosure Acts, and facilitating Bills of that nature; and in such a case it is much to be wished that provision may be made

for a distinct and accurate plan of the shore and adjoining country;—the line of bank with sections thereof being deposited in Parliament and other public places in like manner to those for railways, but also accompanied with a specification of the intended works. Perhaps some amendments of the Act of 5 and 6 Victoria, chap. 89, entitled "An Act to promote the Drainage of Lands and the Improvement of Navigation and Water-Power, &c. in Ireland," would answer the purpose. The 7 and 8 Vict., chap. 110, regulating the liabilities of public companies and partnerships, may also bear on this question, and an Act may from these be framed which would enable the public and individuals to judge of the extent and probable effect of these projects, and to take measures accordingly for their own protection; besides the suppression of those inflated expectations which are raised by exaggerated accounts of quantity of land proposed to be gained, and by the boastful and confident, yet mysterious air assumed by adventurers on such occasions, which, if not intended to lead, do in fact lead to ruinous participations in ill-digested projects, and even to failure in designs very capable of eminent success under prudent and well-advised management.

Assuming, therefore, that the public ought to be protected from enticement to invest their money under representations of too sanguine, and therefore of a somewhat fictitious nature, it follows that these parlia-

mentary documents ought to exhibit measurements of the quantity of land proposed to be gained from the sea, and an authentic estimate of the probable expenses to be incurred therein, together with an account of the nature and probable produce and value of the soil when drained and reclaimed after embankment, and the probable expenses thereof, and that these plans, specifications, estimates, and valuations, shall be certified and signed by at least two engineers *and* two land-surveyors: and indeed such precautions as these are equally requisite for the benefit of the adventurers, as for security to the public; since nothing is more common than for such adventurers to deceive *themselves*, quite as much as they deceive their monied friends; nor can it be conceived that educated and well-informed men, ardently bent on such schemes, should draw their friends into them with any other than *bonâ fide* views of certain advantage to both. Nor does it appear that these guards ought to be omitted any more in the case of private parties undertaking the project, than in the case of a Joint Stock Company; since the original undertaking parties change, and if there is any delusion in the scheme, its propagation is facilitated by the want of those guards. It may also be worthy of consideration, whether the public points and bearings of such matters should not be matter of investigation by Government; thus the projectors might be referred to the Board

of Ordnance or Board of Trade, who should issue a writ of *ad quod damnum* directed to certain persons acting as Commissioners, who should report as to how far, and in what way, the public are concerned in the matter, as is already done with regard to navigation, and that such report should be referred as instructions to the Committee on the Bill.

2nd, The due provisions for the rights of the PROPRIETORS of land adjoining, who may be affected by these projects of embanking lands from the sea, and those especially who have been denominated frontagers, are next to be the subject of our consideration, although the amount and probable value of some of those rights in such cases have already been touched upon. Any such Bill proposed to Parliament with the object of such embankment, drainage, and reclamation of lands from the sea, whilst it gives powers to the promoters sufficient to carry out their project, must also carefully guard against abuse of those powers by invasion of, or injury to, property, without ample compensation, and this compensation will be of a twofold nature, viz. for the property taken, and for injury to other property.

The property actually taken away will chiefly, if not entirely, comprise that which has been previously described and estimated, as share of frontage and pasturable fringes, which should be wholly vested in the undertakers in fee, when the sea has been shut

out by them; but if any accident should occasion the final abandonment of the project, it would be hard on the frontager to lose his slob and fringes in fee; therefore a proviso should be made, that if at any period whatever, the sea should again break in, and the breach made thereby should be and remain open, and the reserved rents thereof unpaid for three whole years, then the slobs and fringes should revert again to the original proprietors. Any buildings, however, may be removed from the premises within one year after the three years aforesaid, but the materials of any roads should not be removed. Yet any stone or other material which constituted part of the bank, and not being the earth thereof, may be removed therefrom at the pleasure of the undertakers. These stipulations may be thought too specific for the clauses of an Act of Parliament, but they ought certainly to be embodied in an agreement which the Act should recognize and confirm. They may also be thought to anticipate a possible failure, but it is only a reasonable degree of prudence to provide for possibilities as well as probabilities; and when it is considered how annoying to a proprietor must be a part of his estate neither well occupied nor altogether abandoned, perfectly useless to him, and scarcely less so to others, the propriety of providing for an event that *may* happen will be apparent.

For all the processes which are to take place during the operation of the Act, such as the setting out of proportions reserved to the proprietary parties, or the supply of materials to the projectors, or in other ways affecting adjoining properties, the Commissioners named therein will act as arbiters in all matters and things which may require to be adjusted between the proprietary and the projecting parties; and in framing the clauses for this purpose, care should be taken to provide some remedy, in case of one of the parties being unwilling to make a reference to the Commissioners in due form, or to abide by their decision when made. Whether in such a case the alternative should be reference to a jury, or whether the Commissioners should be allowed to proceed *ex parte* after the lapse of a certain period of time, and after notices to the obstinate party of their intentions to proceed, are points for consideration; but it should be recollected that it is most desirable that the parties should adjust all these points between themselves, without incurring the extra expenses of arbiters, and therefore that the alternative of their non-adjustment between themselves should not be too easy and cheap, but be attended with that amount of trouble and expense which may have the effect of discouraging arbitration, and consequently of encouraging private agreement. At the same time it must be considered that for any man's private property to be entered

and taken for the private profit of any other man, is of itself a great grievance, and the compensation for such entry and appropriation should be ample, and such as ought reasonably to afford satisfaction to the parties suffering without being extravagant; and this principle is now recognized in railway compensations, to find which, the full value of ground taken is increased by a consideration for severance and unwilling sale, to an amount varying from one-third more than the intrinsic value to double that value of the land. Indeed the mode of compensation, as well as the powers of projectors in railway cases, are now so well studied and understood, and have been so matured in practice, that no better modes and powers could be adopted in the case of intakes than those in operation with respect to railways; although they go the length of powers to the projectors to take and convert property to their own use without individual consent of the possessors of that property. There is, however, this difference between the cases, viz. that in railways the exact line and dimensions of the property required are previously known and understood, so that the proprietors and projectors are often enabled to come to an understanding before the Bill passes, and thus a good deal of time and expense are saved; whereas, in the present state of intake practice, the plans and specifications of the works intended are not sufficiently defined beforehand to

admit of such desirable and beneficial adjustments of interests; a defect which should be cured, not only in the manner already specified with respect to the lines and sections of the embankment, but also by defining and describing the situations from which materials are required to be taken, the nature and probable amount of them, and the lines of road by which they are to be carried. Nothing could be easier than this, under that well-considered and well-digested plan upon which such measures should be based; and the proprietors have a right to know what is required of them previously to the introduction of the Bill into Parliament. This knowledge ought to extend to all parts of the proposed works which are likely to affect their property, including the catchwater drains, and other interferences with existing rights and interests; and far from being a hardship on the projectors, this particularity would be so far beneficial to them as to tend greatly to that well-advised and mature consideration of the subject which the ordinary sanguine temperament of projectors renders so essential to their own success, as well as to the interests of those capitalists with whom they are connected.

It would also conduce greatly to the prevention of disputes if the Act were to recognize some principle or rule of boundary to the frontages of proprietors, and this could not perhaps be better done than by showing the lines of the respective frontages over the

intake on the parliamentary plans and sections, or otherwise by naming some point of the compass which these lines shall bear; or, by drawing a line from one end of the coast to the other, the bearings of the frontages with respect to that line could be described in words in some clauses of the Act. In short, the very reverse of what usually takes place in the framing of Bills for Parliament on such matters ought to be adopted, for these Bills are usually got up in haste; some of the clauses are unusual, and therefore out of precedency in the process of legislation; words are necessarily introduced foreign to those already recognized in that process, and the efforts made to reduce clauses to parliamentary forms, and words to parliamentary language, and the efforts of individuals to secure their respective interests, induce so many alterations, that by the time the Bill becomes an Act, its original compiler would not be able to recognize it as the result of his own labours; and what he, with a full knowledge of the subject, considered the essence of its efficacy, is destroyed by its amendments. This was very much the case in almost the only precedent for such Acts, viz. 1 and 2 Vict. (1838), chap. 87, entitled "The Lough Swilly and Lough Foyle Drainage and Embankment Act." In this Act the Commissioners nominated were several gentlemen of consideration, of local knowledge, and of habits of business. These of course could only act through the medium

of engineers and surveyors employed by themselves, and according to evidence adduced before them as to the facts of the case. This, therefore, is a species of arbitration, not a Commissionership, though so named. Here the proprietors are left to make the best bargain they can with the projectors, and failing that, to have recourse to referees named in the Act. But the persons named in the Act as Commissioners should be professional men, of business habits, invested with powers to carry the Act into execution, to arrange, adjust, and determine all matters and things between the proprietors and projectors, under and subject to the terms and conditions and provisoes of the Act, until the land to be embanked shall be finally vested. And this might be done in the same manner as landed property is dealt with under Inclosure Acts, either of common fields or waste lands, wherein the property of all the proprietors in the parish or manor is operated upon by such persons so nominated, each property being taken out of the hands of its ancient possessors, and put into a state known amongst lawyers as that of *hotch-potch* or *hotch-pot*, meaning a mixed or amalgamated state, out of which it is the business of the Commissioners to bring each proprietor's share in due proportions.

This process under Inclosure Acts is a much more extensive dealing with private property than is contemplated in the case of an intake, where

some of the principal outlines of the rights of proprietors and of the powers of projectors would be laid down and defined by the Act; and the chief duties of the Commissioners would be to determine minor matters of value, and of mutual convenience to the parties. But even in the exercise of such limited powers as these, such guards would be required to be provided by the Act as would obviate the danger of either party seeking to render them nugatory; such as the guard of giving power for the Commissioners to act on the application of one party or the other, and also such a guard as may declare whether, and how far, and in what cases, the adjournment of a Commissioners' meeting may be requisite: thus, the Act should declare that when any specific matter or thing between the parties shall be submitted to the Commissioners, as mentioned and specified in the Notice to act served on the Commissioners by the one or other party, such specific matter or thing shall be adjusted by the Commissioners, either at their first meeting or any other meeting, whether by adjournment or otherwise. It is, besides, extremely necessary in all such Acts to guard against the possibility of one or other party delaying proceedings and conclusions, to the manifest injury of the opposite party; thus, whilst the proprietor should not be allowed to withhold materials and accommodations beyond a reasonable period against the projectors, the latter should not be enabled to

withhold payment for the same: and this brings us to

3rd, The consideration of what is due to the PROJECTORS in the case of such an adventure of their skill and capital as that which we are contemplating, viz. an intake or embankment of lands from the sea.

The general principles on which such rights, &c. will be founded, are, that every possible facility and encouragement should be afforded to the projectors, consistently with the rights of the public and of the proprietors or frontagers.

The projectors should have power to enter upon lands, and take materials fit and proper for their purpose; also to make roads for the conveyance thereof, and to make catchwater drains, and to erect temporary buildings, and for all other purposes that the prosecution of their work may require. But these powers should be under every reasonable restriction that may be necessary for the interests and convenience of the proprietors, without too much reducing the powers of the projectors. For instance, materials, &c. may be wanted instanter. It would be too much to restrict their being taken at three, or even one month's notice, and yet some notice and some forms are called for. These forms may differ according to the stage at which the work may have arrived, because in the beginning thereof the projectors can readily foresee what materials will be

required, and in what situations. But occurrences may take place afterwards, which may require materials to be taken suddenly or at any short notice; therefore the Act should contain powers, and require the Commissioners named therein, to set out in the *first instance* requisite materials, and the road by which they may be carried, &c., and to value the same, and to give notice to all parties concerned therein, of such setting out and valuation, and of the particulars thereof, together with a plan of the ground required to be taken for materials; such notice to be delivered to the parties interested at least two months before any such property shall be entered on for the purposes of the Act; and if any party so interested shall feel aggrieved, by reason of such setting out or valuation so made by the said Commissioners, and shall give notice of his dissatisfaction within one month of the delivery of notice by the Commissioners as aforesaid, then, and in that case, a jury shall be empannelled by the Sheriff, who shall hear the evidence adduced by the parties on both sides, viz. by the projectors on the one side, and the proprietors on the other, and their determination shall be final, and the expenses of the said jury shall be borne equally between the said parties, the whole of the said expenses being first defrayed by the projectors, and one moiety thereof being retained by them out of the compensation money awarded by the jury.

The projectors should also be enabled at a future period to embank any further portion of the shore than that laid down as their exterior line of bank; and the extent of their rights over such portion as remains unembanked should be clearly defined by the Act; saving to the public and to the frontage proprietors, until embanked, such rights and privileges as they have been hitherto accustomed to enjoy in, on, and over such unembanked shores.

The projectors should also be allowed to enjoy all the advantages which their bank may afford, towards promoting trade thereon by landing-places, wharfs, quays, warehouses, &c., without hindrance from the frontagers, but in certain localities regulated by the Act.

Any public roads made by them should afterwards be maintained and kept up in the same manner as other public roads are kept up in the district.

In consideration of the great expense of such works, no public burthens, as county-rate, poor-rate, (tithe is abolished upon such lands,) or other public tax or assessment whatever, whether local or otherwise, should be levied upon the lands embanked during the first seven years, to be computed from the day of the commencement of the year of any assessment next after the final shutting out of the sea, as the same may be certified by the Commissioners; and this privilege might be accorded in and by the pre-

paratory Act before mentioned, on the same grounds that "barren lands" were exempted from tithes for the first seven years after cultivation.

The projectors having executed the works of embankment and drainage, the several distinct intakes, or embankment enclosures, are to be erected into *levels*, bearing such denominations as may be mentioned in the Act, or in any document referred to by the same; and after being so erected into a level, a provision is to be made for the due maintenance and repair of the said banks, and sluices, and steam engines, by the appointment of Trustees for each level respectively, and by means of an acreable rate laid upon such embanked lands by such Trustees, who are to consist of owners of lands within the said level, or their nominees. The qualification for such Trusteeship should not be too low, as that might let in a troublesome majority of small owners, who would rather risk the chance of inundation than incur expense. The qualification should rather be high, to secure respectable votes: the actual possession of fifty acres appears to be a fair medium in most cases, but may be too large in some cases, or too small in others. The Trustees should have power to levy an acreable rate to any needful amount by the votes of two-thirds in number *and* two-thirds in value, neuters being considered as consents, and such votes to be in writing signed by

the party or their agents. But such rate ought not to be uniform and even over the whole level, since some of the lower lands will require more draining than others which are higher, whilst all the lands will equally require the protection of the bank; there should accordingly be an equal acreable rate for the support of the bank, but the rate for drainage should be levied according to the situation of the lands, at least three distinctions being made, say into *high lands*, *medium lands*, and *low lands*, and the drainage rate should be levied accordingly. If it were otherwise, the burden of draining the lower lands would be partly thrown on the higher levels of the intake, and in case of the projectors having taken in too much of the lowest land, with too much water standing thereon, the upper levels of land would be injured thereby, inasmuch as the necessity for steam engines would probably be entirely owing to this circumstance. This principle of classification in the expense of drainage has always been recognized and acted on; for so far back as the first drainage of the Fens in Bedford Level, in 1667, they were divided, according to their degree of lowness and difficulty of drainage, into eleven qualities, varying from each other by a quantity which was expressed by fourpence per acre difference of drainage tax, and this has continued to the present day. The Trustees therefore, for the drainage of each level,

should be empowered and required by the Act to assess the drainage taxes on the lands of each level, according to the necessity and difficulty of their drainage, and to cause a classification of such lands to be made accordingly, before they proceed to levy any drainage taxes.

And whether the projectors shall consist of private individuals or a public Joint Stock Company, the lands embanked should be vested in them in fee for every purpose of ownership, subject, however, to the foregoing proviso in case of a "*drown*," as soon as they are fairly and actually won from the sea, and the requisite means taken for their general drainage from land waters, and also the shares of frontagers or other proprietors set out, unless such shares have been reserved in money rents, which on many accounts would be the most desirable for the projectors as well as the frontagers. These things being done and certified by the Commissioners, or some other such competent authority as can be implicitly depended on by the public, the lands so won should be vested in the projectors with full powers of sale, and every facility should be given by the Act to enable them to make good and sufficient titles to any portion of the lands, whether large or small; and with this view, the Act should contain a scheduled form of conveyance, and should enjoin that a map or plan be annexed thereto, showing the exterior line of boundary of such lands,

and also the line of access thereto through or across any other lands to the nearest public road, and also the access to the sea, and also the direction and nature of its drainage, and also its means of supply of fresh water, if any; and the conveyance should declare its class of drainage, and its apportioned share of the head rent, together with all other particulars of its incumbrances, or the burthens that may affect the lands so conveyed.

And here it may be well to notice how extremely important it is for the projectors to obtain a *bonâ fide* declaration as to the sufficiency of the banks to protect the lands from the sea, and of the sluices or other means of drainage to carry off the land waters; since, in such a case, little confidence can be expected to be placed in the certificates of the very same Commissioners who have conducted the works and will of course deem them good and sufficient. For such a purpose as this, public characters well known in the country, and having the aid of engineers, surveyors, and others of their own choosing, afford at first sight a good guarantee, but on reflection the public will be apt to look upon the engineers, surveyors, and others so employed, as the real authorities on which such certificates are given: it seems therefore essential for the projectors to stand well with the public on this important point, that some public Court should be constituted to take cognizance of this matter; and whether such Court

would best be a Jury convened by the Sheriff or the Grand Jury of the county, or the Chairman of Quarter Sessions, hearing evidence as to the fact of the directions of the Act having been fulfilled, *and* also that the works of embankment and drainage are good and sufficient, may be matter of consideration in any particular case; but certain it is, that for the interests of the projectors, neither too much publicity, scrutiny, nor candour can possibly be infused into such an inquiry.

In all such Acts of Parliament the use of the essential words "embanking, draining, and reclaiming," should be limited to their precise meaning, and used in their proper places: to use the word *draining* precedently to the word *embanking* in such a case is to put the cart before the horse; yet parliamentary usage may call for the word *draining* or *drainage* to stand first, because Drainage Bills are frequent, but Embankment Bills are scarcely known,—and this is one more reason in favour of such a general, or declaratory, or regulatory Act, with regard to measures of this kind, as has been recommended.

Such an Act should declare, that the word *embanking* means the act of shutting out the sea from some portion of the land which has been hitherto covered by it, and that the words *sea-bank*, or *bank*, or *embankment*, mean, the bank which so shuts out the sea; that the word *draining* or *drainage* means the carrying off to seaward, or the discharge beyond the bank to

seaward, of those waters which may fall upon the lands from which the sea is so shut out, either by downfall of rain or by waters from other lands above their level; and that this drainage means the discharge of such waters from the level, so as to admit of the cultivation of the same, except as to certain portions, viz. the fleets and water-fences.

Some confusion of ideas will also arise, unless the meaning of the words *reclaiming* or *reclamation* be well defined by the Act; they are sometimes used as synonymous to embanking and draining, whereas their true meaning applies to those agricultural operations which take place subsequently to the embanking and draining, viz. the subdivision, fencing, and the cultivation of the land.

It is, in short, very essential to the interests of the projectors, and may save them much expense and litigation, to have the Act as clear and specific, and with as little ambiguity as possible, with regard to the nature and extent of their rights and powers, discarding not only as unworthy, but impolitic, those contradictions which are sometimes permitted, advantage being afterwards taken of the confusion occasioned by them. Whilst, therefore, the projectors should be favoured in every way possible consistently with the rights of the proprietors, they ought to expect to be bound to render a full and fair measure of justice to those proprietors as well as to the public.

IX. EXAMPLES OF EMBANKMENTS.

One may be familiarly acquainted with many miles of sea-bank without becoming cognizant of those particulars of their construction which we now wish to develope, in order to elucidate our discourse by a reference to facts.

The following instances may serve to exemplify some of the points already mentioned.

1. An embankment was made after the opening of the Nene Cut in 1824, to form the rampart-road over Cross Keys Wash, and about 1200 acres of sandy soil were thus enclosed by a cradge-bank, some of the land having brought £40 an acre immediately, and the whole realized £26,000.

And the river Nene Outfall Commissioners, together with some adjoining proprietors, were (July, 1844) embanking a portion of the salt-marsh to seaward of the Cross Keys, or Sutton Wash rampart.

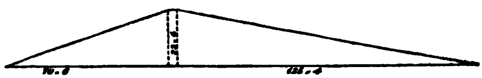
According to Sir John Rennie's printed Report of November, 1839, their line is 3 miles 2 furlongs 270 links in length, and is 2 miles 4050 links below

Sutton Bridge, enclosing about 4000 acres. Sir John recommended that bushes should be inserted in the bare silt or sands, with their tops standing out in lines across the direction of the flow of tide, in order to gather the silt and raise the surface. This was done, and several feet in depth of silt have been gathered in channels and other low places: as the tide comes up very turbid and surcharged with warp, the bush-tops create a certain extent of still water, and this allows the sediment to deposit and accumulate to a considerable degree, *i. e.* 5 or 6 feet deep in one year, in rills and channels where circumstances are favourable; the conditions requisite to this effect being that the flow of tide shall be merely checked sufficiently to produce still water, not stopped or so much impeded as to produce an eddy or an overfall. A bank across and stopping suddenly the usual efflux of the tide has also a similar effect, which is strongly evinced by the accumulation of soil in front of the rampart or Sutton Wash road, where a fine strong golty silt has accumulated to the depth of several feet during the twenty years since that bank was made; and this accumulation has become covered, first with samphire, and then with maritime grasses (on which sheep do well), and with few rills or creeks. The sands thus accumulated become covered with a slimy vegetation, which Sir John Rennie calls "cot or ling, the forerunner of samphire," as soon as their stability is established, *i.e.* in one

summer, and then the samphire appears, which gives place as the sands rise to maritime grasses.

One great portion of the expense of this work is incurred by the necessity of what are called "cradge-banks," which enclose portions of the space to be finally embanked. Thus along the edge of the high-lands or skirts which had been raised by the warp or accumulation of silt before mentioned, little difficulty was experienced in embanking 1200 acres of the high fringe next the land, with a cradge-bank with slopes 3 to 1 to sea, and 1 to 1 on land side. This, however, had not experienced the effects of a stormy winter. Other cradge-banks have been made, and are intended to be made, for the double purpose of reducing the area of tidal water to be contended against at one time; *i. e.* of cutting off portions of the enemy, and of raising the land; which latter operation not only reduces the water in depth and force, but also makes the land more valuable when embanked. The benefit of these cradge-banks is thought to be so great, that although they do in fact constitute many temporary intakes in addition to one permanent embankment, yet the parties are constructing as many of them as will ultimately reduce the space from which the water is to be finally excluded, to a few, say 500 acres,—on the principle of lessening the force of the reflux tide, at or about the critical period of closing or shutting out the tide altogether.

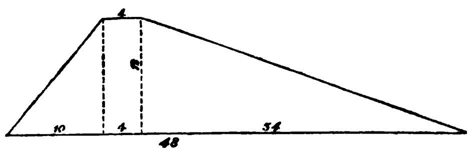
On this line of embankment the tide flowed according to the sections to a maximum depth of 19 feet at extraordinary spring tides, and at 17 feet 6 inches at ordinary spring tides; and the bank was constructed 6 feet above the latter height, and 30 feet above low-water mark. It was covered with chalk-stone from Hesse, on the Humber, to ordinary high-water mark, and turfed above; the slope being 5½ to 1 to sea-ward, and 3 to 1 to landward, the top to be 4 feet broad, according to which dimensions its section would be as below.



It had been found that the mere barrowing and loose packing of the cradge-banks had caused them to break and wash down, from the water getting between the sandy sods and rendering them somewhat buoyant. Carts and horses were therefore employed to raise the main bank, that its solidity might be increased by their pressure, and the expense of them in raising the banks was not found greater than barrowing the sand from the sand-banks adjacent,—being done at about 7*s.* per floor, or under sixpence per cubic yard. Three feet thick of clay was placed against the sand on sea side, and 18 inches thick on land side, and both were well sodded outside. The clay was brought oy tram-roads from a marsh at one end of the bank, about 1½ mile distance.

A considerable portion of the main bank remained to be completed, including the most critical operation of closing or finally shutting out the tide. This operation was looked to with anxiety,—the fine-grained, tender, and loose sand had begun to work away fast with the reflux tide, and no plan had yet been determined on as to the mode of closing the breach.

2. The bank minuted by Arthur Young, in 1784, as having been built by Count Bentinck, near Terrington, extended about four miles and enclosed about 1000 acres, and its dimensions were 12 feet high, 34 feet base in front, 4 feet thick at top, and 10 feet base in rear, which would give the following section:



This cost £5 per rod forward, but for want of height and slope in front at first a breach happened, and an expense of about £1000 was incurred, which is included in the £5 per rod. It may therefore be inferred from the particulars given, that this bank cost about fourpence halfpenny per cubic yard, the soil being a somewhat clayey silt.

3. Another bank in the same locality is mentioned by Arthur Young, as erected about the year 1800, and the dimensions given are 12 feet high, 4 feet thick at

top, sea base 4 to 1, and land base 2 to 1,— dimensions which give the following section:

The cost of labour was 4*s.* 6*d.* per floor of 400 feet, which is 3½*d.* per cubic yard, men finding barrows, planks, &c.; the whole cost of bank, sluices, &c. being £3300, but ultimately £4000 for 273 acres of marsh and 18 acres of bank, or between £13 and £14 per acre. It was sown directly the sea was shut out with coleseed and wheat, and both crops were good. £4 an acre was offered for four years, £3 for six years. Let in 1802 for 42*s.* to 52*s.* 6*d.* per acre. Price of wheat in 1801, six guineas per quarter.

4. Arthur Young also gives some particulars of the bank built 1790, to enclose 868 acres of common at Terrington, as follows:

The bank cost, and was then deserted, the sea breaking in, ...	£4,535
But was afterwards completed for . .	8,032
Sluice	309
A partition bank	254
Act, Solicitors, &c.	759
Commissioners, &c.	514
Survey	200
Sundries	2,367
Total	12,435

or rather more than £14 per acre. Let at 20*s*. to 42*s*. per acre. Average 30*s*.

5. Young's account of the Essex sea-walls, in the agricultural report of that county, mentions the following:

(*a*.) Thirty acres embanked at Goldhanger cost £300. (*b*.) Ten acres at Bradwell cost £150. (*c*.) Three hundred and thirty acres in Foulness Island in 1801, the bank being 420 rods, costing about £3 per rod, which is under £4 per acre; but the whole cost £1700, or under £5 per acre, was enclosed by tenants under a 21 years' lease, rent free, but not to be ploughed. In four years after enclosure, he "examined the herbage, and found it greatly advanced and very good, the white clover coming apace, and a scattering of *dwarf poa* and spotted trefoil, with many other grasses that promise to do well."

6. The following example deserves attention:

Extract from Trans. Soc. Arts, 1800. Letter from the Rev. Sir Henry Bate Dudley to the Secretary; dated Bradwell Lodge, Essex, 17th of December, 1799.

"A tract of land which I enclosed on the same line of coast within this parish, about eleven years ago, (for which I was then honoured with the Society's gold medal,) being already under a profitable course of tillage, I was induced to undertake

the present enclosure, as a lessee of the Collegiate estate of St. Paul's. The front line of embankment against the sea is nearly one mile in length, and, with the returning banks on each wing to the old wall, forms an enclosure of 260 acres. The whole of the embankment is composed of earth alone, barrowed from the irregular salting land in front, and taken at the limited distance of 12 feet from the base of the new work, to leave a sufficient fore-land for its protection. I found from experience in my former embankment, that I had not given a sufficient angular declension in front, for an easy ascent and descent of the waves. This error was therefore corrected in the last work. I began it on a base of 32 feet and wrought it to the height of 7 feet, leaving it a plane of 5 feet on the top, and making the land side of the embankment as nearly perpendicular as the security of the base would allow.

"Within, on the land side, is cut a ditch 12 feet wide, 5 feet deep, and 4 feet at bottom; the earth from which was thrown into the mound. My former sea embankment in Bradwell parish had nearly given way to the great inundating tide of February, 1792, from this erection of new earth being made on the surface. To guard against similar danger in the present work, a spit-deep trench, 6 feet wide, was previously cut along the centre of the whole line, on which the mound was to rest; this, by admit-

ting the new earth into an incorporative adhesion with the base soil, renders a future separation almost impossible. Before this, the main rills had been filled and rammed, to give these parts an equal solidity with the rest.

"The whole operation was performed by a gang of sea-wallers, with barrows and planks only, at £1. 10*s.* the marsh rod of 20 feet, and perfectly enclosed in seven months; but it must be observed; that the soil, composed of rich vegetable matter, is without one particle of stone or gravel, and cuts with an iron-edged scoop-tool, so as to load the barrows with great facility. At each end of the front line is laid an outfall gutter, or sluice, through the whole embankment, 5 feet in width by 3 feet deep, clear in the run, and another of smaller dimensions in the centre, for discharging the land waters freely to sea. The construction of these aqueducts is too well known to require further description here; probably, however, the little addition given to those erected on this occasion may be found of some use. Observing it often happen, that, either from accident or design, the outward lid of the sea-sluices remained open, and admitted the tide to the great injury of the fresh waters inside the marshes, I introduced here a light fly-lid within the centre of each sluice, which is out of reach, and yields to the slightest pressure of the water going out; but shuts

closely against that of the tide, when it passes inwardly the external flap. These sluices are laid upon as solid a foundation as can artificially be made on such soils, to prevent the crabs, and other sea-fish, from undermining them, which must otherwise be the case. The frame and flooring are of fir, which lies under water as durably as oak.

"The land thus enclosed is partitioned into four nearly equal parts, by new out-ditches 12 feet wide, 5 feet deep, and 4 feet at the bottom, which, with small intersecting rills from various parts, give the whole a good drainage of its salts on the fall of heavy rains; and, by a course recently made from a distant brook, each division of this land is now amply supplied with fresh water. Not less than 800 South Down sheep, and from 60 to 80 horses, are almost constantly grazed, and even winter thereon remarkably well. The established opinion of the best farmers of the country was, that lands thus taken from the sea would not grow corn under 30 years, at least, after their enclosure. But, as no experiment had been made, by which this fact could be clearly ascertained, as soon as I had shut out the sea from part of it, about 6 yards square were immediately dug, and sown with horse-beans and oats, which, though the summer proved very dry, and consequently unfavourable, produced of each a fair return of sound, good corn, and the last har-

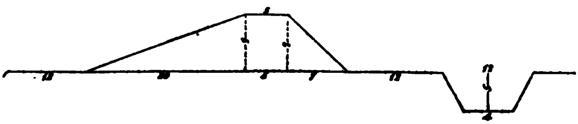
vest, the same spot being sown with wheat, yielded an excellent crop. The next spring, I mean to try it with barley and turnips. My first enclosed lands in this parish have produced two succeeding crops of fine oats, and are now growing a very promising breadth of rape for seed.

"It may here be remarked, that the lower oozy parts of the new enclosure, on which no vegetable ever grew before, begin to be coated with various grasses, and as the saline plants die away in other parts for want of their natural moisture, fresh grasses replace them, so that the whole is now nearly covered with grazing plants of good quality, amongst which appear the different clovers, trefoil, and rye grass, &c. Hence, I conclude, but contrary to the general opinion, that though all these grew artificially from seed sown, it does not follow of necessity that they cannot be produced without. I think that the natural operation of the sun and air upon certain soils will alone effect it, and my experience in lands taken from the sea confirms very strongly this opinion."

The value of every line of this letter would be much enhanced by a knowledge of the talent and energy of the writer, exerted as they were for many years, for the benefit of his neighbourhood and country, as an active and courageous magistrate, an accomplished clergyman, scholar, and

country gentleman, a skilful and enterprising agriculturist, and also a man of literary taste and judgment in the fine arts of his day.

According to the dimensions given, the following would be a section of the sea-bank and delph, &c.;



and the earth-work was done at fourpence per cubic yard.

This example shows how slowly good fixed principles gain ground, or become established, since we have here a man of real genius and observation, adopting (on a second trial) a slope of 3 to 1 in front, whereas 5 to 1 is the proper slope.

7. Arthur Young also, speaking of the embankments of Lincolnshire in the Agricultural Report of that county, says that at Wintringham (on the Humber) beans were sown the second year after excluding the sea, but the crop was very bad, which was attributed to the salt. He adds, "From observations made in other places, I am inclined to think that the land should be pastured for three years after excluding the sea."

8. The "white sands" as they are called, forming the estuary of the old river Dee, having become vested in "The River Dee Company" about the

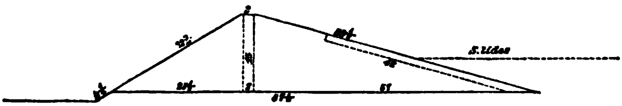
year 1732, have been from time to time embanked from the city of Chester along the shores of Flintshire, and now produce a revenue of several, say nine or ten thousand pounds a year.

The land is now extremely productive and valuable, and there is coal beneath it at Mostyn, &c., to a valuable extent, which is worked to great advantage. The railway compensation for lands of this kind ranged from £150 to £300 per acre, along the line of the Chester and Holyhead Railway; but some portions of it, particularly about Rhyll, are light and sandy. About Chester, culture has brought these "white sands" to a good soil, but the banks of the fences still show the original white running sand.

Davis, in his Agricultural Report of North Wales, enumerates seven Acts of Parliament passed from 1778 to 1794, by which 18,900 acres were embanked and enclosed in that county, including 3100 acres of the above-mentioned Dee lands, the share of the Lords of the manor, in four instances, being two instances each $\frac{1}{12}$ths, one $\frac{1}{15}$th, and one $\frac{1}{16}$th. He mentions 1700 acres more as very capable of embankment with advantage, and some such have since taken place.

9. In 1843 a bank or "cop" was built by the joint efforts of the Hon. E. M. Ll. Mostyn, and J. P. Eyton, Esq., called the Bychan embankment, situated between Llanerchy-mor smelting-works and

Mostyn colliery in Flintshire, being on the western estuary and near the mouth of the river Dee. Its dimensions are, base $87\frac{1}{2}$ feet, height 16 feet, sea-side slope $59\frac{1}{2}$ feet, of which 42 feet from the foot were stoned, landside slope $32\frac{3}{4}$ feet, and 2 feet wide at top, giving the following section.



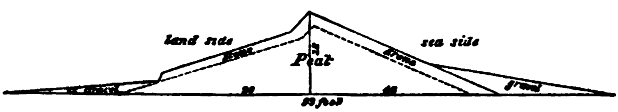
The length of the bank is 1974 yards, or rather more than one mile and an eighth. The cost was £4500, less the barrows and planks which were used in making up the bank with the sea-sand on the spot, and might be worth £50 when completed. The cost therefore would be £4000 a mile, or as nearly as possible sixpence per cubic yard for the whole, including stone, which however was not placed over the whole face. When first laid on, the stones were thrown promiscuously on a layer of straw, gorse, or brushwood, which was put on the face of the sand, but the winter tides brought a part of the stones down to the base, and it was found expedient to replace them edgeways, paving them regularly and smoothly on the surface, in which process it is found that the larger the upper stones are, the better. The distance the stone had to be carried was about a mile and a quarter, and the cost was 13*d.* per ton, viz. $4\frac{1}{2}$*d.* quarrying and $8\frac{1}{2}$*d.* drawing; the total

cost was reckoned at 3*s.* per square yard. The part not stone-faced was covered with sods in two thicknesses, each being about eight inches thick; but where stone was used, the sods from them to the top of the bank were only 2½ inches thick, cut with a push plough; the inside slope was cut 3½ feet deeper than the level outside, so as to have a larger facing, and to put a cover to make it a cart-road. The highest spring tides on the sands outside of the bank do not rise more than 7 feet *on the bank*, if in a quiet state, but in stormy winds blowing into the estuary, the waves reach nearly to the top of the bank. The land obtained is about 70 acres, but it is in a situation which gives it great local value, and with a probability of coal beneath. The Chester and Holyhead Railway will pass through it. The back of the bank will be sown with lucerne, of which there will be 4½ acres.

10. A sea-bank was built in 1819 to 1824 at Rossbegh, on the coast of Kerry, in the extreme south of Ireland, excluding the sea from about 400 acres by a bank of only 4700 links, or little more than half a mile in length, the situation being a nook, but the course of a river had to be turned. The soil was partly bog, overflowed by high spring tides, partly rich black mud, partly sand and gravel with black stinking matter, and partly shelly sand; the tide in the old bed of the river, and in other channels, rose 10 to 15 feet above their surface, but

at each end of the bank the ground was somewhat rising, and the general height of the bank was 12 feet. The bank was built of the peat of the bog, brought in barges, the sand of the foundation not being disturbed. Stones from a quarry near were laid as a foundation for the peat, and with these were intermixed heath or fir twigs to bind them together, and the peat was defended in front and weighted with 1½ to 2 feet of stone, according to its situation and exposure, laid in larch twigs and heath, and also lined at the back with stone, of somewhat less thickness. The bank has a slope in front of about 4 to 1, and has a foot of gravel 12 to 15 feet wide, forming a natural beach at the lower part of the slope. The face of the bank has a slight dip, and comes to a ridge of stone at top, which is about 3 feet above the highest tides, and where above the ordinary springs is covered with a spontaneous growth of sand rush (*arundo arenaria*), and some bog plants, whilst the stone facing grows sea-weed to the spring tide height.

The annexed diagram shows the section of this bank and the arrangement of its materials:



The sluices are placed in pairs, namely, two of

18 inches run each, two of 3 feet run each, two of 4 feet run each, and two more of 3 feet run each, making 23 feet run in all; and although most of the upland waters are discharged separately and independently by a catchwater drain, the springs which rise in, and the rain which falls on, this intake, give these sluices all they can perform to keep down the waters without a great loss of land in lakes and wet low places. They are placed within a foot of the lowest ebb, and run from one to four hours according to the ebb out to sea and the water pressing against the sluice-doors inside. The sandy portion of the intake was a good deal washed, and its position altered during the building of the bank, in consequence of an attempt to build across without a gap, using the lake thus formed inside as a navigation by which to bring the materials at all times of tide, but this occasioned a breach in the spring after the unfinished bank had sustained the stormy lake on one side, and the sea on the other during the winter. This breach again altered the position of the sandy soil, and nearly levelled in the channels, reducing the original general level of the land, which proved low and wet, and much saturated with salt. The boggy part of the land was earthed and cultivated, and the low sandy part was planted with the stolones of the *agrostis maritima* or sea fiorin, which grew vigorously, and

was eaten with avidity by the cattle. The surface of this low part was not disturbed, and the pasturage was improving fast, when another breach happened, the bank blowing up, and a breach of about 30 yards wide taking place, apparently on the site of one of the old channels, where the sand might be supposed to be less consolidated than the rest. This was soon made up again, and it was found that so much sand had rushed in from seaward, that it had very beneficially raised the surface of the intake. The fiorin was again planted and the surface drained by open grips, and the pasturage is extremely good and yearly improving, the white clover and good grasses appearing spontaneously, especially where the droppings of the cattle supply the seeds, there being a large extent of sand-hills attached to the intake where the cattle range, and which affords a shift or change, though they prefer the intake in bad weather, it being sheltered by the sand-hills. The whole is capable of maintaining 160 head of cattle, viz., 40 four-year old beasts, 40 three-year olds, 40 two-year olds, and 40 calves; but its present stock is not quite so great, some dry cows and some horses being grazed, for which the portion in meadow cuts yearly about 75 tons of hay, besides about 50 acres of tillage, on which about 12 to 15 acres of very fine potatoes are grown yearly; the course being, potatoes 1,—potatoes 2,—oats 3,—seeds

mown 4,—seeds fed 5,—seeds fed 6. The cattle are housed in yards with sheds, and 30 were selected either for the butcher, or to be stall-fed this winter (1844), with the potatoes and hay, half of them here, and the others on another farm. Of the soils, the bog has become the tillage; the rich black mud has become the chief meadowing; the sandy and gravelly black slob is pasturage, good in proportion to its drainage; and the shelly sand is the same where low, and where high, is disposed to blow into sand-hills, provincially called "stooks," which become slowly covered with grass.

These are the leading facts of the embankment, drainage, and reclamation of this intake, but there are some circumstances of an interesting nature attending it, which deserve to be recorded.

The slobs or shore lands, thus embanked, were part of an extensive mountain property, very thickly peopled with small occupiers, who, in consequence of the great and sudden fall of times, *i. e.* the prices of the produce of land, from 1813, got into arrears; their rents were reduced, and it was thought that if they could be brought to render the arrears in labour, a change might be wrought in their moral condition, which was very low. This they did willingly, the better tenants by their cotters, and the smaller by themselves, each man receiving instead of money a ticket to be booked for a day's work,

and in this manner several thousand pounds were worked out; and the smaller tenants have ever since continued to work out such a portion of their rents as it might not have been easy for them to pay in money, by reason of the smallness of their holdings and the wildness of the country. This undertaking was not a speculation for pecuniary gain; we shall not therefore go into the question of expense, except to say that it is judged to be already paying a good interest on the actual money expended; but for other more important purposes it has succeeded admirably, viz. the marked and highly beneficial improvement of the habits and character of a large population, and a vast improvement in their farming and their farms.

[This bank has, since the above account was written, blown up in consequence of Otters having formed a lodgement amongst its materials.]

11. Some embankments have taken place under 1 and 2 Vict., chap. 87, a special Act for that purpose, along the shores of Lough Foyle, in the county Derry, Ireland, which seem likely to prove but the commencement of similar, or perhaps more important undertakings, in that highly improvable country. About 3500 acres have been excluded from the sea on the south side of this Lough, and as the soil in general affords every indication of the highest fertility, great ultimate returns are expected.

Two different modes have been adopted by different parties in this undertaking; one having raised his bank by barrows and planks with the soil of the shore on the spot, which is a sandy silt or sea-mud drying into a whitish shelly sand composed of very minute particles; the other party having run out his earthy material and stone from the shore, upon tram-roads and waggons, drawn both by horses and locomotive engines. The whole face of the bank from foot to top is *pitched* with stone 18 inches deep, set edgeways, with a slope of about 4 to 1 more than half-way up, and then somewhat steeper to the top, which is 4 feet wide. The spring tide here rises 9 or 10 feet, but the outbursts are great, and the top of the banks will be, say 16 feet above the low-water line.

Both parties have experienced those accidents to which these undertakings are subject, viz. very high tides before completion washing away material, leading to the conclusion that it is better to make up the bank to its full height at once as it proceeds, and also the conclusion that sufficient *height* is the one thing needful, and that the want of it is the rock upon which all these kinds of works are most likely to split; an error which will, in cases under notice, be carefully guarded against, so far as skill and capital can effect such security.

12. The Report to Parliament of the Commis-

sioners of Woods and Forests, 1838, gives the following account of Sunk Island, on the Humber, an estate entirely gained from the sea:

"This estate has been gradually formed by the accumulation of the warp or soil deposited by the river Humber. It was first granted on lease, on the 18th December, 1668, to Anthony Gillry, Esq., for a term of 31 years at a rent of £5 per annum, when it was described as containing 3500 acres of drowned ground." He was to embank 100 acres in ten years, but failed to do so; and in 1675 a new lease was granted of 99 years at the same rent, and in 1744 there had been embanked 1560 acres. In 1755 a new lease was granted at a fine of 1000 guineas and same rent. In 1771 another lease was granted at a fine of £1550 and £100 rent, expiring 15th March, 1802; previous to which a survey was made by the Crown, finding 1561 A. 0 R. 14 P. embanked, and 2700 acres fit to embank at an estimated cost of £8940. 18*s.* 0*d.*, or say £10,000. The estate would then be worth £3400 per annum — tenant to do this, and to pay £704. 2*s.* 6*d.* first year, £2000 for the second year, and £3190 per annum for the rest of the term for 31 years from 5th April, 1802. This term expired in 1833, when there were 5929 A. 1 R. 13 P. of land of excellent quality in fifteen farms. The Crown then valued the estate at £9814 a-year, but the tenant

contended that it was only worth £5205, and it was ultimately let to the occupying under-tenants at £9140. 10*s.*; tenants keeping all banks, jetties, and other sea-defences in repair, and to lay out £8793. 9*s.* 3*d.* in various requisite buildings. In 1831 the Crown built a church, and endowed it with £250 per annum; and in 1836 the Crown gave £5000 towards making a road to Ottringham.

It may be remarked of these examples;—1st, That their usual mode of construction has been in right lines of 3 to 5 feet base to 1 perpendicular, and 4 to 5 feet top. 2nd, That such a construction adopted with regard to a bank of 17½ feet high, like that shown in the diagram A, p. 26, would give a sectional area of nearly 1000 feet; whereas the diagram but little exceeds half that quantity, yet is more effectual. 3rd, That the actual cost of raising the earth-work of these banks was under sixpence per cubic yard, whereas we have calculated the cost at twice that rate of expense, so as effectually to cover the cost, not only of the most difficult cases of embankment, but also to allow amply for the effect of tides in washing away the material, and causing repetitions of the work.

13. Monsieur De Luc, the well-known scientific protegé of Queen Charlotte, consort of King George III., has already been quoted as to the singular mode of facing sea-banks with straw ropes. He gives in the

1st vol. of his 'Geological Travels,' 1810, and for geological purposes, a very diffuse but interesting account of the embanked marshes and other low lands of the coast of the North Sea at the mouths of the Eyder and Elbe. We shall therefore condense his account for the benefit of embankers, using as much as possible his own words, — first, however, premising that the extent of the sea-banks on these coasts is not less than 350 miles, and the area of marsh lands considerably above half a million of acres; that the usual height of these banks is 20 to 22 feet above low-water mark, and the rise of tide 13 feet, the width of the top being 12 to 18 feet in many parts: on some of these banks two loads of hay can pass, and they form in wet seasons the chief roads of the marsh districts, although many towns and villages are built in them.

De Luc traces the history of these embankments to so early a date as when the unsettled tribes called "Sea-Warriors," having gradually planted themselves on the marshy islands, were swept off to the number of 600,— they being ignorant of the dreadful effects of a certain association of circumstances, rare indeed, but when occurring, absolutely destructive to the marshes. This association consists of an extraordinary elevation of the level of the North Sea from the long continuance of certain winds in the Atlantic, with a violent storm occurring during the tides of the new or full moon, for then the tide rises above the level of all the marshes;

and before they were secured against such attacks, the waves rolling over them and tearing away the grass which had bound their surface, they were reduced to the state of mere banks of sand and mud, whence they had been drawn by the long course of ordinary causes. Such were the dreadful accidents to which the first settlers on these lands were exposed; but no sooner were they over than ordinary causes began to act,—the sand-banks rose, their surface was covered with grass, the coast was thus extended, and new islands were formed,—time effaced the impression of past misfortunes, and those amongst the inhabitants of these dangerous soils who had been able to save themselves on the coast ventured to return to settle on them again, and had time to multiply before the recurrence of the same catastrophe. The first step in the progress of sea-banking seems to have been to raise mounds of earth in the centre or other highest parts of these marshy islands, and for the people to reside with their families and cattle upon these mounds, letting the tide flow around them; and there are still such islands so inhabited by many families, forming parishes with churches, and those islands are called "*halligs*."

The marshes continued in this state for a long period, during which such catastrophes as those mentioned above occasionally took place. It was after one of these that the enclosing of these marshes by sea-banks, walls, or dikes, was first commenced. They

dug ditches around all the marshes, heaping up on their exterior edge the earth that was taken out, and thus they exposed to the sea *dikes* of 8 feet in height. After this they undertook to unite the islands with each other by dikes or banks surrounding the higher parts of the sands lying between those islands; these *dikes* were called *hoogs,* and they gathered soil very fast, because the sea there comes up very turbid, and deposits a great sediment before the ebb of tide, and this has been the rise and progress of the art of building *dikes* along all the coasts of the North Sea, particularly those of Sleswick and Holstein. But the grounds thus gained from the sand-banks were very insecure,—these people, though they had inhabited them more than ten centuries, had not yet understood that combination of fatal circumstances above described, against which their *dikes* formed but a very feeble rampart. After several serious demonstrations of this insufficiency occurring at intervals of 39, 44, and 46 years, an outburst of the sea, happening at 12 years from the last considerable event of that kind, swept off 10,000 of the inhabitants. In 86 years more, seven entire parishes were destroyed, and in 38 years more, two considerable embanked islands were overwhelmed; afterwards at two periods great outbursts and damage took place, and during a long period of time the inhabitants who survived these catastrophes, and their successors, were so much discouraged, that they attempted nothing more

than to surround with dikes like the former such spaces of their marsh land as appeared to be the least exposed to these ravages, leaving the rest to its fate. But the common course of causes continually tending to extend and to raise the grassy parts of the sand-banks, and no extraordinary combinations of circumstances having interrupted these natural operations, later generations, further advanced in the arts, undertook to secure to themselves the possession of these new grounds. Sixty-three years after the last great catastrophe they turned their attention to the stoppage of these ravages, which the sea was still making in continuation of its former devastations, by cutting creeks and enlarging former breaches. In the front of all these creeks they planted stakes, which they interlaced with osiers, leaving a certain space between the lines. The waves thus broken could no longer do injury to the marsh, and their sediments being deposited on both sides of this fence, very solid *forelands* were soon formed. In 25 years more they raised the dikes considerably higher, employing wheel-barrows for the first time for this purpose; they much enlarged and deepened the interior canals (the *delph*) in order to obtain more earth, not merely to add to the height of the dikes, but to *extend their base on the outer side.*

But the marshes became in as great danger on the side towards the Continent as on that open to the sea, because the rivers coming down between the embanked

island marshes and the sea were injurious to the dikes; it therefore became necessary to join the islands to the mainland, but with a sluiced channel to let off the land waters.

Under these improvements and the use of straw ropes, a comparative degree of security and repose was enjoyed for the space of 119 years, when the sea rising to an excessive height, carried away during a great tempest the *hoogs* constructed between the islands of Pellworm and Nordstrand, which have ever since continued distinct islands: it also attacked Ditmarsh, and its ravages extended over the whole coast, 120 miles in direct length, and as far as the very extensive slands of Jutland. The Government then interfered to the assistance of the sufferers, and sent engineers to repair the banks, bringing them somewhat to their present dimension.

De Luc describes the mode of preparing for new intakes by joining the mud and sand banks accumulated outside to the dike by means of small banks not quite so high as ordinary top of tide, with openings here and there, by which the receding tide passes off slowly and deposits its sediment: he says, "This junction of the *foreland* with the dike is very essential to the safety of the latter, and for the purpose of producing *forelands* before this dike, where none are naturally formed, rows of small *dikes* are raised in the water in a direction across that taken by the tides,

and in general by the waves. This operation is begun by planting double lines of small stakes, not rising quite to the common level of high water: these stakes serve to confine the clay of which the *dikes* are formed, their upper surface being covered with straw ropes. The tides and waves pass over these smaller dikes, but as it is only through some openings that they can retreat, they deposit their sediments in the intervals between the dikes, and when these sediments are accumulated nearly to the high-water level, vegetation begins to overspread them; the spaces are quickly filled quite up, and a solid soil is formed.

During great storms with certain winds, if the turf is once torn away in any part, the thickness of the *dike* by no means secures it from being bored entirely through, and the water rushing in at this opening pours down in a torrent upon the marsh, producing there a vast excavation at the point of its fall. If, however, after the storm is over, the lower part of the *dike* is found not to have been attacked, the accident is not of great consequence; the water let in upon the marsh runs off at low water; a number of men with wheel-barrows soon raise a barrier against the high tides, and the dike is afterwards completely repaired. But if the very base of the dike has been excavated, much more labour is required; the dike can neither be built in the same place on account of the soft state to which the ground is reduced, nor

conveniently within the marsh, because a recess would then be formed into which the waves would rush with increased force; a basis must therefore be formed for it without on the foreland, a portion of which is enclosed with a wide curve. The excavation is thus left within where it occasions no danger, not containing water of sufficient extent to be raised up in waves by the wind, and it is soon filled up with reeds. The first step of this operation is to construct a small dike against the high tides, and the principal dike is then formed within it.

All these intakes are made *between* the rivers coming down from the high lands.

The sluices are the points where the dikes require the greatest vigilance; supervisors are lodged near every sluice within the dike, and are provided with all the necessary tools and materials, that they may be ready to repair even the smallest breach. These openings are secured by a very strong wall, but as this could not stand if it had no other foundation than the soil of the marsh itself, large blocks are sunk in that soil, in order to render it firm. But the points of junction of these walls with the dike must never be neglected, for hard and soft bodies do not unite, and the turf which serves as a rampart to the dike will not unite to the walls. Now, if during violent tempests the waves should find the smallest aperture in these points of junction, they

would dilute the earth and make their way entirely through the dike. The sluices which close these openings move in grooves made in the walls. In summer time nothing more is commonly necessary than to keep them shut to exclude the high tides; the rain waters are carried sufficiently off from the marsh by evaporation, and the water in the drains is even maintained at a certain height, in order to preserve such a degree of moisture as may favour the growth of the grass, and preserve the ground from cracking. In rainy weather, or during the melting of the snows, each sluice is raised by a windlass at the moment when the level of the sea has sunk below that of the marsh, the water of which thus runs off till the rising tide has nearly reached the same level, and the sluices are again let down.

In using the *straw-facing*, the men employed kneel with their backs to the sea, having beside them bundles of straw, of which they make ropes an inch or two in thickness. When they have made one about a foot long, they press the middle part of it into the soil of the dike to the depth of several inches with a kind of forked chisel, the two points of which prevent the rope from opening while pressed down by the flat part between them. With that end of it which remains out, they interweave fresh straw, and when they have lengthened sufficiently, they again press it down into the dike

at the distance of 5 or 6 inches from the former place. This work is carried on all along the dike from the top to the bottom, each new rope being laid close to the preceding as regularly as in a beehive. The grass soon springs up between the straw ropes, and after a certain time entirely conceals them, but when they become rotten they are no longer of use.

These outbursts are matters of great interest to those who engage in embanking lands from the sea. On the eastern coasts of England they usually happen in off-shore winds, but after an in-shore wind has prevailed for some time. Thus the Dean (sandy dunes) of Yarmouth is inundated with a westerly wind suddenly occurring after a long-continued easterly wind, and the moon new or full. Without attempting the *rationale* of this phenomenon, we may hazard the conjecture that the east wind, together with a spring tide, having given the sea a strong tendency towards the land, the west wind, blowing at an angle of 45° against the sea at some little distance from the land, prevents its falling, and the wind losing its force in blowing over the land, does not prevent the sea rushing with unusual violence towards the land, as into a comparative vacuum.

14. Mr. Vancouver, in his Report of Devonshire, made to the Board of Agriculture in 1813, says, that his experience in such matters in Ireland, Holland, and America, enables him to conclude, that a

crude tough black sea-mud is, when dry, the most rigid and intractable of all argillaceous compounds, and quite unfit for embanking, but that salt marsh, properly so called, when ripe and ready for embankment, is the mildest, most temperate, and permanently fruitful soil of any; but before its embankment it should have been raised by tidal accessions to nearly, if not quite, the height of the ordinary flow of spring tides. In proportion as all embankments from the sea have been made between these points of high and low water mark, they have answered or disappointed the views of the undertakers.

Mr. Vancouver gives an instance of an eligible subject for embankment in Braunton, near Barnstaple, as a level of very fine salt marsh, which in a long succession of ages, by a constant and regular deposition of sediment made by the tidal waters, appears to have risen to nearly the highest level of ordinary spring tides. The upper soil of this marsh consists of a tender, rich, soapy, hazel-coloured loam on a subsoil of silt or fine sand, below which a coarser stratum of sand occurs, in which gradations it seems to have arisen from a dark blue or rather black tenacious galt or clay, the usual character of common sea-mud.

The marsh has an area of about 1200 acres; it is covered with a carpet or fine matting of all the plants and grasses peculiar to such situations, and

is subject to be occasionally submerged to a slight depth by the tidal waters. He further says, "The tender hazel-coloured loam which forms the soil of all salt marsh ready for embankment being formed of animal and vegetable exuvia, combined with the finest particles of terrene matter that the tidal waters could hold in suspension, can never fail yielding the most ample returns when rescued from the ocean." Also, "A tract of salt marsh ready for enclosing was observed near the mouth of the river Otter, having arrived to nearly the highest level of spring tides, and covered with marsh samphire, thrift, ladies cushion, and a luxuriant growth of *artiplex partulacorides*."

15. Arthur Young, in his Report on the county of Essex, 1807, has the following passage: "As a guard to a sea-wall much exposed and newly repaired by Mr. Dudley (afterwards Sir Henry, before quoted,) he attempted to give a new direction to a shifting bank of shells, to convert it into a defence and security to his wall: for this purpose he made a fagot hedge in the sea-ooze, to retain the shell sand, and finding it to take effect, he made a second, and the bank shifts, though slowly, to his will."

16. In the same author's Report on Lincolnshire, 1799, he has the following remarks on this subject: "Ten thousand acres have been saved from the sea in the parish of Long Sutton, and 7000 more might now be taken by altering the channel of the river."

"Holland Fen (many thousand acres) is a country that absolutely exists but by the security of its banks; they are under Commissioners, and very well attended to."

"In taking in new tracts by embankment, it is always an object of consequence to determine the appropriation of the land. At Winteringham (30 miles up the Humber) the failure of beans sown the second year after excluding the sea seemed owing to the too great softness of the soil, although the beans were good where the drainage was best on the highest spots, but in flat places none." He thought the land should be pastured for three years after excluding the sea, after which ploughing will succeed. Great tracts of valuable land remain yet to be taken in from the sea about North Somercoates, and other places on the coast (of Lincolnshire),—the sea ebbing out for two miles; every mile of coast, therefore, has 1280 acres of frontage. But I do not find that any experiments have been made in Sir Hyde Page's method (a great engineer of that day) of making hedges of gorse fascines, and leaving the sand to accumulate itself into a bank—although the natives have observed, that if a gorse-bush, or any other impediment, was by accident met with by the sea, it was sure to form a hillock of sand.

"South Holland, grossly estimated at 100,000 acres

within the old sea-dike bank, has long been an object of embankment. Ravenbank, the origin of which is quite unknown, appears to have been the third which had been formed for securing a part of this tract from the sea. About six miles nearer to the sea is the old sea-dike bank, unquestionably a Roman work. The origin and date of the fifth bank, called the New Sea-Dike, two miles nearer the sea than the Roman, is unknown. The new or sixth bank, made under an Act in 1792, encloses a breadth of two miles more, and in taking the requisite levels it was found that the surface of the country at the Roman bank suddenly rose six feet higher on the sea side than the land side, and continued so to seaward, being the depth of warp or till deposited by the sea since that bank was made."

17. Embanking lands on the Humber and Trent is often but a prelude to the process of warping, of which Sir G. Head, in his 'Tour through the Manufacturing Counties,' gives the following account: "The process is performed by subjecting the lands to be warped to the ingress and egress of the tide, until by a gradual accumulation of strata, one, two, three, or four feet of mould, as may be required, are deposited over the barren waste, and what was before a heathy moor, is converted to a state of exuberant fertility. The excessive richness of the crops and soil were most extraordinary; the wheat, beans, flax,

and potatoes were wonderfully fine; and the soft black friable earth in rows along the roots of the potatoes might have passed, every particle of it, through a fine hair sieve."

In one case of embankment and warping on the Trent, 184 acres of peat moss were embanked, and took 150 men 8 months. The tide was let in for three years, the water 5 feet deep, and the warp was raised from 1 to 4 feet. It took one year to settle, then was sown with grass seeds at the end of summer. In July following it was covered with white clover, and fed 70 horses, 36 oxen, and 160 sheep, but (purposely and judiciously) much understocked. After three or four years it was to be ploughed. The ploughed warp-lands produce immense crops so long as their freshness continues; the rotations are,— 1 oats, 2 oats, 3 fallow for rape (fed off), 4 wheat, 5 oats, 6 rape, 7 wheat, 8 beans, 9 wheat, or perhaps a repetition for many years of 1 beans, 2 wheat. Potatoes for the London market formerly yielded a good return, and then wheat was grown 6 to 8 qrs. per acre, beans 10 qrs., oats 10 to 12 qrs. per acre. Warp-lands have been sold since the war prices at £100 per acre, and when exhausted they are often renewable by fresh warping.

X. OF THE REPAIR AND SUPPORT OF OLD SEA-WALLS.

The repair and support of sea-banks is a matter of great concern to those who possess marsh or sea-shore estates which depend on such banks for their safety by exclusion of the sea. In such cases, large drawbacks are often suffered from the rental of such estates, and these drawbacks have a tendency either to increase or to diminish, according to the degree of skill and judgment with which the banks are treated. We shall now therefore endeavour to impart some useful portion of that experience on this matter, which has been the growth of a long professional life, very specially and extensively engaged on this particular subject, chiefly in Essex, Suffolk, Norfolk, and Lincolnshire, but also on other parts of the coast, where altogether many thousand acres of rich land are defended from the encroaches of the sea.

The sea-walls in these counties are commonly banks of earth with little slope to seaward, and as steep to landward as the clay or earth with which they are raised will permit. They are generally swarded over

with grass of some kind, but couch grass or twitch forms not only their general, but their best covering and protection, from the matting nature of its roots and its distastefulness to cattle, enabling it to renew itself plentifully by seed as well as root. Most of these banks have existed for ages, but the steepness with which they were originally constructed has frequently caused the assaults of the waves to break away the earthy matter in their front, and to make deep and dangerous impressions in the body of the bank. In other cases the banks, of sufficient height at first, have become lowered by the tread of cattle, and the shrinking and atmospheric waste of the material, so as to become overtopped by the tides, and the lands they protected have been drowned, either with or without a breach of the bank itself. These occurrences have occasioned and rendered necessary a constant attention to the facing, strengthening, and topping of the banks.

The ancient and still practised mode of protecting the face of the bank was by rows of piles driven closely into the face of the bank; the rows about 18 inches apart, forming what were called "*rooms*," which were filled till within the last twenty years with hard chalk, but since with stone; and I have known fourteen of these rooms, one above another, to protect the face of a sea-wall.

But within the last twenty years it has become

pretty generally understood that in the face of a bank, a slope to seaward affords a greater degree of security than these tiers of piles and rooms of chalk, and that such slopes are less expensive to maintain, since the piles were constantly requiring to be renewed and the chalk was continually crumbling away. In all new sea-banks, therefore, totally new principles have been adopted in their construction, and the best of these principles we have already developed in the preceding pages; but as there still remain some hundreds of miles of sea-bank built and maintained upon the old principles, we proceed to explain some of the chief features of their usual, as well as their proper treatment, under the heads of—1. the facing; 2. the topping; 3. the siding and delph; 4. the foreland and footing.

1. In speaking of the facing of a bank we must consider the subject under the heads of (*a*) earth-work; (*b*) turfing or sodding; (*c*) pile and stone-work; (*d*) thatch-wood-work; (*e*) wharfing; (*f*) stone only.

(*a*.) In strengthening the facing of sea-walls with earth-work, when that material is sufficient, the object should be to bring the face of the bank to as much of a slope as possible, and then to cover its surface with any kind of vegetation that may be observed to be adapted to the nature of the soil, such as ray grass and couch grass; or, if the earth be brackish, with such maritime plants as may be found in the vicinity. This

vegetable covering is of great value, and will often supersede the necessity of the more costly protection of stone, &c.; and even the great engineer, Rennie, did not disdain the use of this natural ally to his works. It also often happens where clay sea-banks are found, that there exists in their vicinity shingle banks and shores, and the spreading of this material on the clay face of a bank, striking and pressing it in whilst still moist, could not fail of giving it much stability.

The labour attending the removal of heavy clay is measured either by the floor or by the cubic yard; the floor is the most local, and the cubic yard the most scientific and universal measure. Of the labour upon the cubic yard of earthy matter, some extremely valuable testimonies have been already given in the foregoing pages. The floor of earth differs locally as the perch differs; thus the statute perch is 16½ feet, whilst the marsh or sea-waller's perch is in some places 18 feet, and in others 20 feet. So the floor of earth being the square of the perch, and 1 foot deep, is either 324 feet (generally in practice 320 feet), or 400 feet, as the one or the other perch may locally prevail. It is important to recollect this in putting out or settling for walling-work, since otherwise much confusion and misunderstanding may arise, and sea-walling being done at so much per floor, may inadvertently be measured and paid for by the square of the statute perch or rod of 272 square feet, instead of 320

square feet or 400 feet, as the case may be. The floor in most general use is that of 400 feet, which contains a trifle less than 15 cubic yards, and that quantity is generally calculated. The floor of 320 feet contains rather less than 12 yards cubic, and for the sake of uniformity it is highly useful to reduce these local measures into the more universal denomination of cubic yards.

The labour attending sea-walls is performed by gangs generally consisting of six runners to two fillers, a lad to clean barrows and planks, and three men to pack on the bank,—these proportions, however, somewhat differing with weather, length of run, and other circumstances.

A "run" is the space or distance which a man will run a barrow-full of earth upon a plank without stopping. This on a tolerably level plane will be 100 yards, but as the height rises it will be less. A stout man will run the distance of 100 yards about 9 cubic yards occasionally, but 6 yards generally, per day, of heavy clay. A man will *pack* or "*store*" nearly as much as three men can *run*. This is called also "*flood-flanking*," and by this operation the "*spits*" of earth are made to fit, and the sorts of earth mixed properly. To gain a "height" the planks are placed on one or more square open boxes, which are called "*box-horses*."

Now according to observations and experience of

sea-walling, a floor of 320 feet may be run and packed for 5*s*. 6*d*., or 5½*d*. per cubic yard. But 6*s*. per floor of 320 feet, or 7*s*. 6*d*. per floor of 400 feet, being 6*d*. per cubic yard, will cover every expense,—allow a fair profit to the head waller for the use of his planks, barrows, and box-horses, and the laying out of his money and time of superintendence, and enable hard-working men to earn good wages, whilst the run is within 100 yards, and nearly level,—and this also allows for interruptions by the tide.

But in cases of removing yielding earth on dry land, without interruptions of water, it is worth one penny per cubic yard to dig up, and about threepence to barrow, 100 yards. And for a good digging soil, 4*s*. 6*d*. per floor is a good price for a floor of 400 feet, to be moved 100 yards, which is threepence halfpenny per cubic yard.

But the labour of moving earth increases so much with the increase of height and distance, that it will amount in some cases to 12*s*. per floor, or 9*d*. per cubic yard, to perform it with planks and barrows, even without the interruption of water. In most such cases, however, as we are now contemplating, viz. the repair of sea-walls, the earthy matter requisite for that purpose may be removed and placed in the required position, with due care, for sixpence per cubic yard.

(*b*.) Turfing or sodding the earthed face of sea-

banks is a common and very useful practice, when the sward is sufficiently plentiful for that purpose. Count Bentinck's sea-bank, in 1800, cost to sod, according to Arthur Young, something more than 4*s.* per floor of 400 square feet, or about one penny per square yard, and the men earned 5*s.* 6*d.* to 7*s.* 6*d.* per day. This is the sum allowed in estimating railway work, which includes "re-sodding," *i. e.* taking off and replacing sod on the vegetable mould.

(*c.*) Piles and stone-facing have already been mentioned as formerly constantly employed, and still much in use for protecting old sea-walls; and these have been described in general terms, as consisting of tiers of piles driven close to each other, in rows about 18 inches apart, row from row, the foot of one tier being nearly even with the middle of the piles of the tier below, and the space between the tiers filled with chalk or stone, and these *rooms*, as they are called, succeeding each other from the bottom or foot of the bank to its top. In Essex, piles are cut out of small oak or other trees, or the tops of larger trees. Oak piles are of three lengths, viz. 4, 5, and 6 feet, and the number reckoned to a hundred differs according to the length; thus, fourscore of 6-foot piles make the hundred, fivescore of 5-foot piles, and sixscore of 4-foot piles. This brings the price to the same for each length, and on the spot where they are to be used they may be reckoned at

(*d.*) By thatch-work facing we do not mean that mode of facing sea-banks with straw, to which we have alluded in the preceding pages, as practised at the mouth of the Eyder, nor any of those other modes which might be practised perhaps with a certain degree of temporary success; but we allude simply to a mode of facing sea-walls with brushwood, which we have seen, and indeed largely practised on the coast of Essex, and which is there called "thatching."

This peculiar mode of sea-defence has perhaps been adopted in consequence of the great quantity of woodland in the immediate neighbourhood. The general description of this facing is that of fagot-wood arising from underwood of 12 or 14 years' growth, cut and bound to nearly its full length, and, being spread over the face of the bank lengthways up and down, is kept in its place with strong piles which are driven amongst it,—these piles having holes bored at their head to admit a cross pin which presses tightly on the fagot sticks, and these sticks receive the wave, break and disperse it, and prevent its tearing away the earth beneath them to any serious extent. This covering does not, however, prevent the constant or frequent surging of the waves from carrying away a certain portion of the earthy face of bank, and then the wood becomes loose, and almost useless, and requires to have fresh wood drawn in, and the piles driven afresh.

It takes about 50 or 60 fagots to cover a square perch of 320 feet with this kind of thatch, and also 50 piles; the pins are generally of chestnut, of which there is much in the neighbouring woods, growing on stubs as underwood; they are either found in the fagots, or brought separately for the purpose, and the cost may be estimated, as under, per square rod of 18 feet square:

	£	s.	d.
1½ load of fagots at 14*s*. . . .	1	1	0
50 strong piles at 6*d*. . . .	1	5	0
Labour	0	10	0
Total . . .	2	16	0

And when it is considered that the brushwood of this kind of protection seldom lasts more than two or three years, and is not unfrequently carried away in less than one year, although the piles may be more long-lived, we shall not be understood as describing this kind of sea-defence in order to its recommendation, but rather the contrary; especially as in one case the head sea-waller kept a public bakery, and had the old "*thatching*" as his perquisite; and in another instance a small marsh district was thus defended, the sea-wall of which sometimes cost more than the rental of the land defended, and almost always the larger moiety of the rent;

whilst the long-continued contractor for the wood and work was said to be worth £40,000.

Still it may happen that such a mode of facing may be judiciously adopted, in some cases where wood is abundant near, and almost valueless from the facility of obtaining coal, and especially as a temporary expedient, until preparation can be made for a more permanent and efficient covering to exposed sea-walls.

But as to a permanent covering, its cost, even with the precarious prolongation of frequent repair, cannot with interest thereon be reckoned at less than twenty shillings per annum for every square rod of 320 square feet, an annuity worth in ready money full £20, which is a sum many times sufficient to stone the whole exposed face of the bank, as we shall presently demonstrate; and yet where this improvident mode has for a long period prevailed, it may not always be convenient to change the habit for a better.

(*e.*) Wharfing has been a mode of sea-walling formerly practised to some extent on those parts of the coast where timber is plentiful on the estates to which such sea-defences belong. This is a method of facing sea-banks with stout planking set upright, and the joints backed by other planks, the whole being secured by means of land ties and stout connecting bars mortised through their projecting heads,

the earthen bank being closely stowed in the rear of all, in imitation of many of the dikes in Holland, where much timber is used in the sea-defences. The first expense of these wharfed sea-walls is however so great that they are limited to very exposed points, and cannot extend very far on those, and they have been found, after a lapse of a few years, suddenly to fail in some spots where the planking has become decayed; and though the apertures may be small, the reflux wave has drawn out with it an alarming quantity of the earth at the back of the planking, the land ties have become loose, and much expense has been required to restore the strength of the wall, which it would have been good economy to remove, and replace with a sloped bank, faced with stone.

(*f.*) Stone only has of late years been decided on as the best possible material that can be used for facing a sea-wall, even in the most exposed situations. The kind and cost of the stone best adapted to this purpose we have already described, but any kind of stone most conveniently obtained is applicable to the purpose, and the most convenient is the most eligible, because the cheapest. Rounded boulder stones should have such a portion of them broken into angular shapes as may afford a proper key; but every kind of stone admits of some mode of stowage which will secure its stability, provided

the slope of bank be sufficiently gradual to enable it to lie fairly thereon, rendered stationary by its own gravity, without any tendency to slide or roll down, the slightest bias to which will greatly assist the efforts of the sea to displace it. The proper degree of this slope has been demonstrated in the foregoing pages to be 5 base to 1 perpendicular, but this is prescribed for new or original banks, whereas it is not always, nor often, possible to bring steep old sea-walls to such a slope, by means of their being set too near the water's edge, or because of the expense attending the addition of so much material after the original construction. The want of slope must, however, be compensated by piling, and the steeper the front of the wall, the more piling will be requisite to keep the stone in place. A slope of 2 to 1 will require rows of piles at 5 or 6 feet distant along the stoned portion of the bank; but at 3 to 1 slope, these rows need not be closer than 10 feet apart, or if the soil be favourably stiff, fewer piles, or even none; and at 4 to 1 the stones will be secure without any piles; therefore in such cases as require some amendment in the important feature of slope, the greatest efforts should be used to gain as nearly as possible 3 to 1 at least; and if this can be effected, a concave form of facing will be preferable to a straight one, such form nearly corresponding to that of the diagram A,

given in p. 26, as for new sea-banks. In a case where a large quantity of sea-walling was faced with stone, it took 15 tons of stone to lay a floor of 320 square feet, one stone deep, or about 9 to 12 inches, so as to cover the whole surface in such a manner as to render the wave innoxious, but still to allow vegetation amongst the interstices where sufficiently out of water.

The stone and labour cost about 8*s.* 6*d.* per ton, viz., stone 7*s.* (in 1844),—unloading, carrying, and laying, 1*s.* 6*d.* per ton; here then was about 35½ square yards done for about 3*s.* 7*d.* per yard, with a very high price for the stone. Referring, however, to what has been previously said as to the stone facing of new sea-walls, it may be reckoned to be as effectually done on old walls, under circumstances reasonably favourable for procuring stone, at 2*s.* per square yard.

It is, however, sufficiently evident that the quantity of stone here contemplated applies only to those sea-walls which have but an ordinary degree of exposure to the rage of the ocean. More desperate cases will call for a greater weight and better coating of stone, although the strength of such banks by no means depends on the mere quantity of stone deposited upon them. On the contrary, there are instances where the bulk of stone has been the chief cause of expense in the repair and support of

an exposed sea-bank, because the sea has found it easy to displace and roll about a mass of loose stones, piled one upon the other to some feet in depth.

In all such cases, it is absolutely necessary, first, to obtain a slope sufficiently flat to allow of each stone to rest upon its own gravity, or if this be impossible, the stone must be supported by piling. Next, a good and firm bed or foundation must be provided, and then the stones must be packed so as to key each other, and small pebbles or gravel placed so as to insinuate into the interstices and bind all together. In such situations also the face of the bank should be left tolerably smooth, that the wave may have little hold on any sinuosities,—precautions so obvious that their mention can only be excused upon the score of seeing them every day neglected.

The cost of such stone facing as this latter must of course be greatly enhanced; but as a depth of 18 inches of stone facing will probably be as effective as more,—and, if the stones are singly of that depth, still more effective than if smaller and collectively of greater depth, the expense ought not to be more than the following statement bears out. The medium weight of granite, dolomite, limestone and chalk, is within a fraction of two tons per cubic yard. Eighteen inches in depth will be one ton

per square yard, say at 4*s.* to 5*s.* per ton, and the laying or placing will cost from ninepence to one shilling per square yard, making 5*s.* to 6*s.*, which on 35½ yards or a square of 320 feet, being a floor, is, say £8 to £10, and which, being permanent, is greatly more economical than the more transient modes of sea-defence already described. There is, however, a precaution in laying the stone in such situations which will deserve attention where circumstances allow of its adoption, viz. placing small branches, or rather twigs of heath, furze, or larch, beneath and between the stones, which bind them together as one mass, till their position becomes established.

2. We come now to speak of the maintenance of a very essential feature of a sea-bank, viz. its height, which is apt to be diminished by the tread of cattle and the natural degradation occasioned by rains and other causes. The first-named cause of this diminution of height ought to be prevented by limiting the grazing of sea-walls to sheep; but even in this case, the other causes are powerful enough to render much vigilance requisite in restoring the lost height, before any higher tides than usual cause a "*drown*," and this is done by the operation called *topping*, or placing a sufficient quantity of earth on the top of the bank. In this operation allowance must be made for the settling or shrinking of the wet earth generally used, which may be calculated at nearly

one-third of the height to which it is put on. Topping put on 5 feet base, 3 feet at top and 2 feet high, took about one floor (400 feet) to 2½ rods (21 feet), and cost 3*s.* per rod, and in some cases 3*s.* 6*d.* per rod. Another instance of topping, 18 inches deep, and 4 feet wide at top, took one floor to 3 rods, and cost 2*s.* per rod lineal of 320 feet.

3. The back of a sea-wall, and the adjacent feature called the delph, or drain and fence at the land side, are both important features, and require to be managed with care and attention. We shall notice each of these separately.

(*a.*) The *back* of the sea-wall has already been mentioned as requiring a certain degree of slope, not only to give stability to the materials of the bank, but to enable it to derive that support which the matted roots of grasses, and other vegetation, are capable of giving. In old banks this slope becomes lessened in time, and in some cases the bank slips down at the back, or it becomes worn by the tread of cattle. The back of the bank is also sometimes honeycombed by rats, moles, &c., or split by the shrinking of the spits or clods originally used in its construction, and not properly packed and flood-flanked at that time. In either of these cases it requires to be made up by the operation called "*siding,*" or the addition of fresh earth to the

requisite extent. Sometimes this operation is deemed necessary in order to give a greater degree of solidity to banks which appear to be deficient in thickness or substance. Siding is usually measured with a string for the breadth, and the average depth of earth is taken. The earth should be taken from the marsh or land side, and is worth six shillings per floor; but as the material both of siding and fronting sea-walls, when of a tenacious nature and used wet, is apt to shrink in drying, and crack so as to fall away, a process called "sludging" is performed, which consists of plastering up and filling the fissures with sea-mud.

It takes about one floor and a quarter to side a rod in length, in ordinary cases, and the waller gives his men nine shillings per rod lineal, whilst he charges eleven shillings to his employer, the two shillings being to compensate for his time in superintendence, and his planks and barrows; but in another case, seven floors sided a 10-foot wall for 6 rods in length. The expense of siding must, however, of course depend entirely on the quantity of material employed, and this having to be more carefully placed or packed of unequal thickness in places, is worth more than the more bulky work of repairing the bank; it depends however much on the nature of the earth, its distance, and the quantity to be added.

(*b.*) The *delph* has already been described as an adjunct of the sea-wall, and caution has been given not to dig it too near the land foot of the wall, this being often the cause of the slipping down or bulging out of the back of the bank, and of the consequent lowering of the top of the wall, thereby occasioning a necessity for the operations of topping and siding. Should this too near proximity be the case, it would be good policy to dig the delph anew, in the marsh, and fill up the old delph with the excavated material from the new one. Such delphs would be of ample dimensions if 10 feet wide at top, 5 feet wide at bottom, and 5 feet deep, so as to stand with 3 feet 6 inches of water at 18 inches below the surface. Such an excavation will require nearly 25 cubic yards of soil to be thrown out for every 18 feet of length, which, at 2½*d.* per yard, will be about 5*s.* per perch, there being no barrowing or packing unless the distance of the old delph should require it, in which case the work will be extra that of the new delph; but as these dimensions will be rather beyond the usual distance of a "*throw,*" it will perhaps be necessary to give the workmen at least another halfpenny per cubic yard for that quantity.

4. The *foot* and *foreland* of the sea-wall are next to be considered, and on these adjunct features depend much of its security and the expense of its

reparation and support. Viewing them as distinct features, we may remark, that

(*a*.) The *foot* of the wall to seaward requires much attention, for here, like the heel of Achilles, it is most vulnerable, and here any mischief to it is usually commenced by that insidious undermining which Neptune is incessantly exercising, in order to regain the dominion which has been wrested from him. The usual notice of these efforts appears by an abstraction of the foot of the bank, causing a "*steep too*" along its edge; and the usual mode of counteracting this effect was formerly the formation of a "*room*" of piles and stone in the manner already described, even where no other such has been constructed higher up the bank. But it is found that wherever this effect of "*pecking*" the foot took place, it is best and most effectually stopped by first restoring what was lost, and then stoning the foot over a space, broad according to the degree of abrasion, but seldom requiring more than 2 yards, the expense of which is expressed in the foregoing remarks. This, however, applies only to the foot of sea-walls which have a foreland beyond them to seaward. In cases where no such important feature exists, but where the foot of the bank comes down to near the low-water mark, or at least where every tide lashes the bank foot, it may be necessary to consider whether a footing of large stones will be

sufficient without piles, which, as before observed, should, if possible, be avoided,—and whether it may not be necessary or proper on sandy or muddy shores to form a natural beach with gravel amongst the stone. On shingly shores where the pebbly beach is alternately accumulating and escaping, it has been customary on some coasts to line the foot of the wall with what are called "*hakes*," which are fagots staked and pinned down between rows of piles; the quantity of material and the expense of which are as follows, viz.:

	s.	*d.*
15 fagots per rod, at 9*s.* per load of 40 fagots, in the wood	3	4½
12 side piles, 7 pin piles } per rod, at 35*s.* per 100 .	6	7½
Carting, &c.	5	0
Per rod of 18 feet . . .	15	0

But the misfortune of this mode is its want of permanency, decaying in three or four years, so that it cannot be recommended, and it might be prudent in such cases to employ large stones with some piles to keep them in place. The foot of the wall should also in every case be kept free from those channels which are apt to be formed along its line. These should be filled up with earth, and the surface

brought to an inclined plane corresponding with the bank.

(*b.*) The *foreland* is extensive on many parts of the coast, particularly that of Essex, where in some localities hundreds of acres extend beyond the sea-walls. These are called "*saltings*," and the greater the breadth of them outside the intake, the more secure the sea-wall is deemed, since they are only overflowed at spring tides, and they occasion the sea to come up calmly and gradually even when extremely rough in deep water. They wash away in some parts of the coast and gather in others, and they are generally much intersected by "*rills*," "*creeks*," and "*channels*," which the tide cuts nearly down to low-water level, some of which come up to the foot of the bank, and endanger its safety, as previously stated. It is of the utmost importance to preserve these saltings or salts as foreland, and for this purpose various expedients are used to check their going away, and to fill up the *rills* which intersect them. For the first, when the foreland has wasted to within 100 yards, the edges of it are scarped and paved with stone, ponderous according to the exposure of the place, and other circumstances; and to fill up the rills, bushes are placed in them, which collect the warp that comes up with the tide; bridges of earth or dams are also placed across rills, impounding small lakes which gradually grow up, and these

dams are useful for enabling sheep and cattle to retire as the tide rises.

In a case of very turbid waters at the flow of tide, bushes are stuck into the ground or ooze at right angles with the flow of tide; these occasion a sufficient degree of stillness to enable the water to deposit its suspended warp, and thus several feet in depth may be accumulated to fill up hollows and rills.

But where there is no actual foreland, and the safety of the land depends on banks either natural or artificial whose feet are on the tideway, and the shingle banks are shifting, it becomes important to retain those banks along shore, in order to avoid deep waters swelling on and carrying away the banks; and here some expensive works are requisite, such as those called "*horses*" in Essex, and "*groins*" in Sussex and Hants. These are rows of oak piles, not less than 6 × 6 inches, and often 9 × 9 inches, and from 12 to 14 feet long. They are driven into the ooze below the shingle at least 6 feet, and stand 3 feet apart, in such manner that an inch and a half elm plank fits between pile and pile, so as to have alternate piles on each side of the plank, which are spiked to the pile with 12 strong spikes. Three men will drive four of these piles per day; the rows extend out for about 10 rods from the shore, and are always placed at right angles with it; some horses placed at an oblique angle failed, by being

broken up the first storm. The effect is to gather shingle on, or rather to prevent its escape from, the leeward side in winds raking the shore, and the cost of some of them in high times has been estimated at £10 per statute rod. Their distance must be proportioned to the nature of the shore, but 10 to 15 to a mile are sometimes needed. These expensive sea-defences of course constitute a considerable drawback upon the revenue derivable from any property to which they are attached; but as they last a long time when erected with due skill, this drawback may be reduced almost to a trifle by constant care and attention to their support.

It often happens that some particular projecting points are very expensive to sustain, by reason of their exposure, although they themselves protect a long line of bank, and then any mode of retaining the beach upon them becomes extremely valuable. In a case of this sort in practice, a sluice on one side of such a point was lengthened in order to obtain a better run to seaward, and the effect was to gather the shingle about the projecting point, so that it afterwards needed scarcely any repairs. The same effect would have happened by means of a horse, but as the sluice stood but 2 or 3 feet out of the general level of the shingle, it would seem that *horses* of smaller height than those usually erected, viz. 6 feet, would have a better effect.

It is however worth while to consider and determine their absolute necessity,—and this some are inclined to doubt, since the shingle often leaves the beach in spite of them; at best they collect it but on one side, and for a time only, and where the wind is "full on" the shore, the shingle would gather as well without these *horses* as with them.

Therefore we may conclude that a stone footing to the sand-bank, which usually forms the sea-wall of such beaches, would answer better at less expense, and with greater permanency, although we may decline changing the established mode. Such a footing should be of large stones, secured with good piles, and the top of the sand-bank should be carefully kept above the highest wave.

On the general subject of this head, it may be averred, from the experience of many years, and the construction of 30 miles of sea-walls, that they may certainly be brought by judicious treatment to that state of safety, and maintained with that degree of economy, as to no longer cause either a sense of insecurity to property or a serious drawback on its revenues.

(*c.*) It remains to mention a source of loss of property upon such parts of the coast as are cliffy and precipitous, viz. the breaking down of these cliffs, and consequent washing away of the valuable land upon their surface. These effects are particu-

larly injurious upon some parts of the coasts of Essex, where the cliffs are from 20 to 60 feet, and more, in height, and consist of alternating irregular veins or seams of the plastic clays, pebbles, and sands, of crag, and of London clay, with its septaria, selenite, lignite, and pyrites, all confusedly mixed either in thick or thin layers, horizontal or convoluted, in lumps or masses,—indeed under every form, showing the breaking down of those earthy matters from deposits formerly entire, their maceration in the bosom of the ocean, their agitation and partial mixture, and their deposition and final upheaval, as now exposed to observation by the constant assaults of the ocean. But it is not alone those assaults that crumble down these mighty masses, and constantly encroach on the fields above. It is by the aid of land-springs that these injurious effects take place; those springs breaking out upon the face of the cliff, first loosen the soil, which crumbles down to the foot of the cliff, and the sea carries it away, thus making way for another avalanche which quickly follows, till the top is reached, and that also gives way, annihilating for ever perhaps half an acre of valuable land. But all these land-slips are not caused by springs; some of the minor ones are occasioned merely by the wash of the sea at the foot of the cliff, lessening the slope and causing large portions of it to break down; and this latter

effect generally follows the former, since in the spot where the spring operates, an indent is formed, and the sea strives to bring the projections on each side to the same line,—those projections becoming advanced points of attack.

The remedy is twofold, viz. 1st, To carry off the springs in the very ingenious manner practised on the Eastern Counties Railway, on the watery diluvial deposits cut through at so much expense near Brentwood; *i.e.* by a small well concentrating the water from the spring, and a drain from the bottom of the well leading off the water down the bank, and preventing its soaking into the face of the cliff, though a small reservoir, wherever the spring water seems disposed to concentrate, would answer the purpose. 2ndly, By a footing to the bank or cliff of good ponderous stones kept in their places by piles, not a masonry wall, but a strong-built rough wall of angular stones, well "*hitched*" on to each other, and secured by strong piles and planks outside,—or in many cases the stones will remain firm without the piles and planks, if well bedded on the firm soil below the loose shingle. We are aware of the tendency of these land-slips to override any such footing, but submit that such overriding is chiefly owing to the percolation of the springs through the porous soil, the stoppage of which would enable such a footing to sustain the bank. It is, however, only in

cases of palpable land-springs gushing out from the cliff that these downright drains can be depended on to carry them off. In other cases where those springs are hidden, or the escape of water is only occasional in wet times,—as, for instance, in the slopes of railway cuttings,—up and down drains are generally nugatory, and sometimes mischievous. Such bank should be drained with very oblique and very narrow drains 3 feet deep, and one above another, with a tile drain on a sole filled part of the way, say 1 foot, over, with any loose material, and the sward earth over that. Such drains both catch and carry the water, and are sure to be effectual, so that in any case of cliff where the protection of the land above is sufficiently valuable and important, the cliff may be thus protected with little fear of a successful result.

This hint, if rightly carried out, may save many lives, by preventing a slip of railway-bank at the critical moment of a train passing, which is the very moment that such slip is likely to happen from the shake, whilst the soil is saturated with water between two upright channels, called drains.

With this hint we conclude our remarks on embankments,—and in bringing our labours to a close, we do so with the confident hope that we have succeeded at least in collecting and arranging, under the different heads of our discourse, much instructive matter, highly useful to practical men; whilst those before

unacquainted with the nature of sea-banks, and the reclamation of lands from the sea, but whose attention may be drawn to the subject either from the nature of their property, or with a view to the employment of their capital, will find in these pages a collection of facts on which they may with confidence rely, as derived from experience and stated with impartiality, and with which a due attention to their own interests makes it necessary they should be acquainted.

THE END.

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